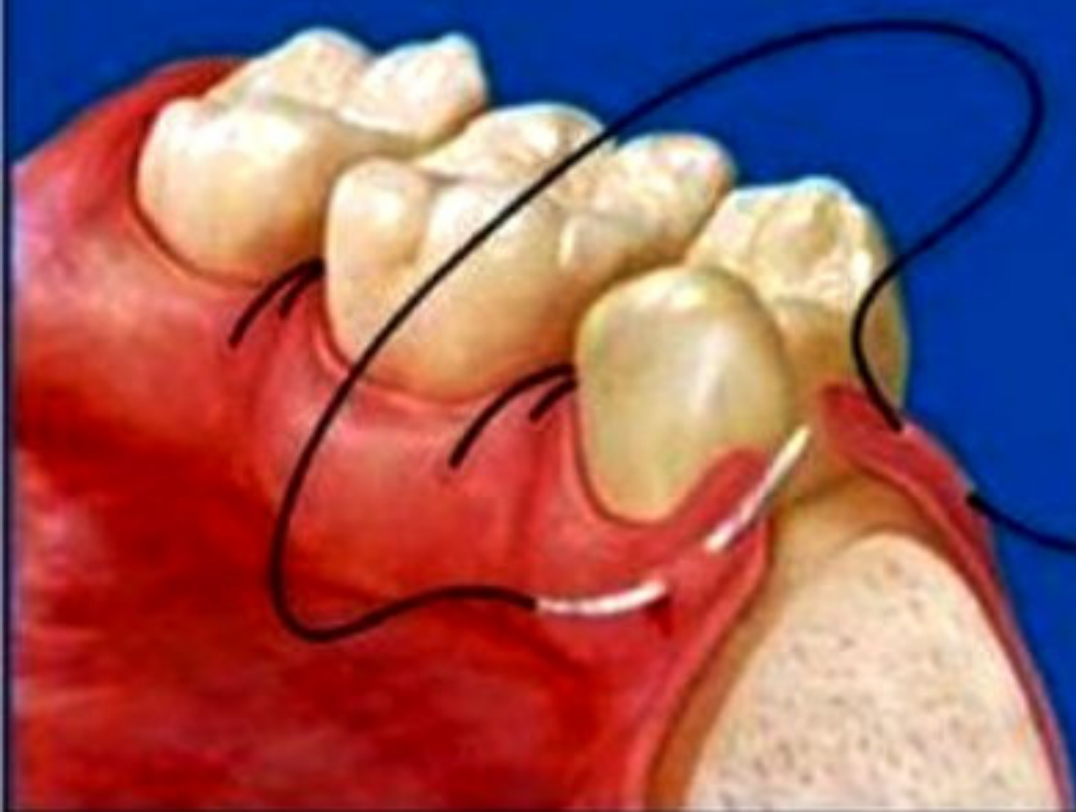


ATLAS OF COSMETIC AND RECONSTRUCTIVE PERIODONTAL SURGERY

THIRD EDITION



EDWARD S.
COHEN

ILLUSTRATED BY
ROBERT ULLRICH

ATLAS OF
**COSMETIC AND
RECONSTRUCTIVE
PERIODONTAL
SURGERY**

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THIRD EDITION

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Notice: The authors and publisher have made every effort to ensure that the patient care recommended herein, including choice of drugs and drug dosages, is in accord with the accepted standard and practice at the time of publication. However, since research and regulation constantly change clinical standards, the reader is urged to check the product information sheet included in the package of each drug, which includes recommended doses, warnings, and contraindications. This is particularly important with new or infrequently used drugs. Any treatment regimen, particularly one involving medication, involves inherent risk that must be weighed on a case-by-case basis against the benefits anticipated. The reader is cautioned that the purpose of this book is to inform and enlighten; the information contained herein is not intended as, and should not be employed as, a substitute for individual diagnosis and treatment.

Dedicated to
Meyer and Milton

Contributors

Arun K. Garg, DMD

Eiji Funakoshi, DDS

Craig Misch, DDS

Dennis Shanelec, DDS

Leonard S. Tibbits, DDS

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Preface

Periodontics is both an art and a science, and this textbook is dedicated to the art of periodontics. The goal of this atlas is to teach the novice, upgrade the skills of the average clinician, and act as a reference source for the experienced clinician.

The modern paradigm for periodontal surgery has significantly changed since the last edition. Esthetics and implantology are now the cornerstones of the modern periodontal practice.

Dental esthetics has altered the way we view our cases. No longer do we treat cases without consideration being given to the facial, dentofacial, and dentogingival elements, especially in the esthetic zone. Procedures have been developed and refined to maintain, augment, and alter the dentogingival elements for the purpose of achieving a satisfactory esthetic result.

Dental implants, although greatly expanding our treatment options, have significantly impacted negatively upon the art of periodontics. Too often teeth are now prematurely extracted for implant placement. As a consequence, clinical skills are reduced and the learning curve is expanded, further reinforcing extraction over treatment. This will change only when there is a greater emphasis placed on treatment and preservation, which is the goal of this atlas.

No textbook of this kind can be completed without the help of others. In that regard, I must take special note to thank Drs. Dennis Shanelec and Leonard S. Tibbits for their section on microsurgery, Drs. Arun K. Garg and Craig Misch for their assistance with the section on mandibular chin and ramus grafts, Dr. Eiji Funakoshi for his section on enamel matrix derivatives and his assistance with the section on osteotomes, Dr. James Hanratty for his clinical contributions, especially to the chapters on mandibular chin grafts and sinus lifts, and Dr. Periklis Proussaefs for his contribution of the Loma Linda technique. I would also like to thank Drs. Scott Kissel, Roger Wise, Federico Brugnami, Irving Glickman, Kenneth Kornman, and George Goumenous for their clinical contributions. Any omissions of recognition are accidental and will be corrected in any future editions.

It must be noted that the chapters written on dental esthetics, esthetic diagnosis, and fundamentals of esthetics relied in large part on the following source material: *The Principles of Visual Perception and Their Clinical Application to Denture Esthetics* by Richard E. Lombardi, *Esthetics of Anterior Fixed Prosthodontics* by Gerard J. Chiche and Alain Pinault, and *Fundamentals of Esthetics* by Claude R. Rufenacht.

I wish to thank the models for this edition of the atlas, Shanon O'Brien-Cohen, Christine Watson, Judith Cohen, and Brigitte Deveraux. Their help was greatly appreciated.

Lastly, special recognition must be given to Robert Ullrich, without whose artwork this and the previous atlases could not have been completed. He is a master medical illustrator whose work has been copied in every textbook and atlas on periodontal surgery.

Edward S. Cohen
Boston, Massachusetts

Preface to the Second Edition

This surgical atlas was originally published with the intent of being the most complete periodontal surgical atlas and in 1988 it was. Since that time, there have been many important advances. The emphasis in periodontics has clearly shifted toward *reconstructive periodontics*. Guided tissue regeneration, biomechanical root preparation, predictable bone regeneration procedures, and cosmetic root coverage have made reconstructive periodontics a reality.

This edition will reflect these changes with new chapters on *biomechanical root preparation, guided tissue regeneration, cosmetic gingival reconstruction, cosmetic treatment of the maxillary anterior teeth, and ridge augmentation, and expansion of the chapter on inductive osseous surgery*. A new chapter has also been added on *sutures and suturing*. All other chapters have been brought up to date, again with the intention of again making this the most complete periodontal surgical atlas.

Any book of this kind requires the help of others in order to be completed. In this regard, a special thanks must go to all those clinicians who so unselfishly contributed material for this edition (alphabetically): Burton Becker, Gerald M. Bowers, Daniel Buser, Robert Del Castillo, Stuart Froum, Bernard Gantes, Gary Golovic, Jan Gottlow, Claude G. Ibbot, L. Laurell, James T. Mellovig, Sture Nyman, Knut Selvig, Richard H. Shanaman, Athenos Spiros, Sigmond Stahl, Dennis P. Tarnow, and Theodore West.

Special acknowledgments must be extended to W.R. Gore Associates, Flagstaff, AZ, and Guidor AB, Gothenburg, Sweden (Guided Tissue Regeneration, Chapter 13) and Ethicon, Inc. Somerville, NJ (Sutures and Suturing, Chapter 2) for their help and permission for parts of their clinical manuals to be incorporated into this atlas.

To my dear friends and associates Bob Ullrich (artwork) and Harry Maskell (photography), without whose talent and expertise this book most surely would not have been completed, I say again thank you.

Edward S. Cohen
Boston, Massachusetts

Preface to the First Edition

Periodontology is both an art and science; as practiced daily, however, it is predominantly a surgical specialty. Although the major periodontal textbooks contain surgical sections, their general nature and scope do not allow for an in-depth analysis of any one specific area. It is for this reason that this text is devoted solely to the art of periodontics and designed for the student, general practitioner, and specialist.

Each procedure has been illustrated and laid out in a step-by-step fashion. Clinical examples have been used secondarily only to supplement illustrations. The descriptive nature of the text is meant to be both brief and simple. Each chapter presents indications, contraindications, advantages, disadvantages, and related problems for each procedure.

This atlas incorporates most of the general techniques and concepts that are outlined in the major textbooks. It can, therefore, easily be used as a supplement to any of these textbooks.

In the course of writing this text, careful attention has been paid to faithfully describing the procedures as they were outlined originally, as well as attempting to give credit to their originators. Any oversights are unintentional and would gladly be corrected in the future. In this regard credit must be given to Glickman's Clinical Periodontology for serving as the model to base the drawings of gingivectomy on and Lindhes: Clinical Periodontology for serving as a guide for the chapter on furcations.

I would like to thank my colleagues Edward Allen, Raul Caffesse, Jose Carvalho, Giovanni Castellucci, David Garber, Barry Jaye, and Edwin Rosenberg for their clinical contributions; Mark Hirsh, Mayer Liebman, and Peter Ferrigno for their helpful suggestions; and my assistants Jeanne McCormack, Rebecca Mugherini, Christine Roberts, and Judith Cohen for their help.

Special notes of acknowledgment must be given to Harry W. Maskell for his photographic excellence; to Robert H. Ullrich, Jr., medical illustrator, for his creative genius in the designing and drawing of the illustrations; and to the educational media department of the New England Medical Center for the pictorial overlays.

Edward S. Cohen
Boston, Massachusetts

Prognosis

The term *prognosis* has been used to indicate the prediction of the future course of a disease in terms of disease outcomes following its onset and/or treatment. As clinicians, we are constantly asked to evaluate the short- and long-term prognosis of both the individual tooth and the overall dentition. This is especially true in complex periodontal prosthetic cases in which treatment decisions are based predominantly on subjective factors. The modern paradigm for periodontal prognosis can be seen in Figure 1-1.

In discussing prognosis, we must first differentiate among *diagnosis*, *risk*, and *prognosis*:

1. Diagnostic factors: factors associated with the analysis and determination of a disease process
2. Risk factors: factors associated with disease development in people who do not yet have the disease (Table 1-1) (Newman and Kornman, 1994)
3. Prognostic factors: factors used to predict disease progression once the disease is present (Table 1-2) (McGuire and Nunn, 1996a)

Newman and colleagues (1994) stated that the terms *risk* and *prognosis* are interchangeable, with “risk most often thought of as the probability of getting the disease (initiation) or having the disease get worse (disease progression).” Kornman and colleagues (2000) noted that we must not confuse risk potential by basing future prognosis on the current diagnostic assessment: “For unlike ‘*diagnosis*’ that looks at ‘*what is*,’ ‘*prognosis*’ determines ‘*what may become*’ of the disease” (Figure 1-2).

Historically, the pathogenesis of human periodontal disease was described by Page and Schroeder (1976). It was agreed that the disease was initiated and perpetuated by a small group of gram-negative anaerobic or microaerophilic bacteria that form subgingival colonies (Page and Kornman, 1997). The process was thought to be continuous in nature (continuous theory) until it was shown to occur episodically or in random bursts (random burst theory) (Haffajee and colleagues, 1983; Haffajee and Socransky 1996). The continuous theory resulted in a simplistic model

Table 1-1 Periodontal Risk Factors

Smoking
Subgingival plaque
Gingival color changes
Initial attachment loss
Probing depth increases
Bleeding on probing
Suppuration
Level of plaque control
Low socioeconomic level
Sporadic dental care
Level of education
Poor dietary habits
Infectious and other acquired diseases
Side effects of medication

Adapted from Newman and Kornman (1994).

of periodontal progression, which assumed all plaque to be similar, with equal susceptibility for everyone (Figure 1-3) (McGuire, 2000).

Clinical paradigms for prognosis were then based predominantly on environmental or anatomic factors that limited or increased plaque

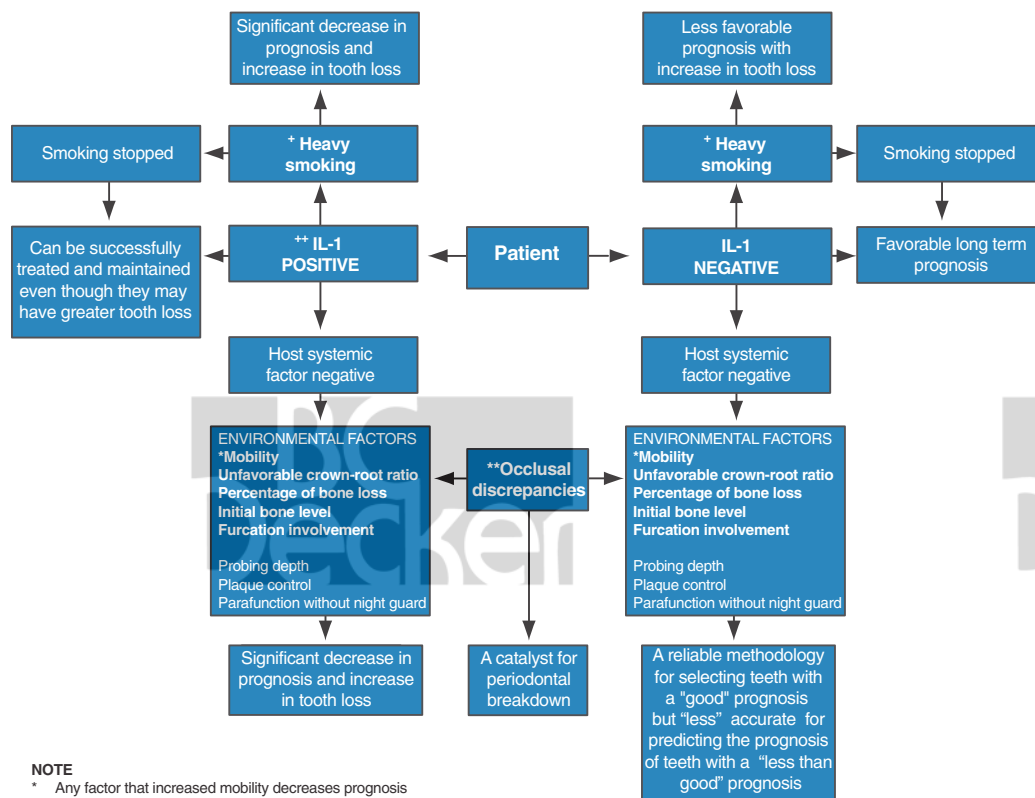


FIGURE 1-1. Periodontal paradigm for determining prognosis.

Table 1-2 Commonly Taught Clinical Factors Used in Assigning Prognosis

Individual tooth prognosis
Percentage of bone loss
Deepest probing depth (in mm)
Horizontal or vertical bone loss
Deepest furcation involvement: 0, 1, 2, 3
Mobility: 0, 1, 2, 3
Crown-to-root ratio: favorable or unfavorable
Root form: favorable or unfavorable
Caries or pulpal involvement: yes or no
Tooth malposition: yes or no
Fixed or removable abutment: yes or no
Overall prognosis
Age
Significant medical history (smoker and/or diabetic)
Family history of periodontal disease (mother, father, sibling): yes or no and whom
Hygiene: good, fair, poor
Compliant: yes or no
Maintenance interval: 2 months, 2 months alternate, 3 months, 3 months alternate
Parafunctional habit with bite guard
Parafunctional habit without bite guard

Adapted from McGuire and Newman (1996).

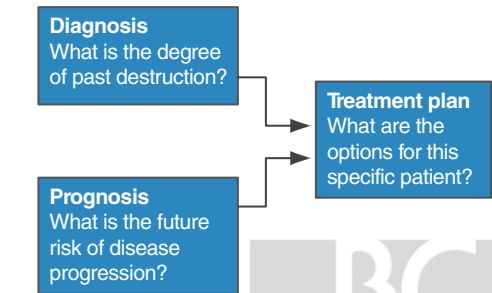


FIGURE 1-2. Treatment analysis.

development (see Table 1-2). Clinical theorems were developed based solely on anatomic factors (Tjan, 1986):

- 1. Ante’s law: periodontal surface area rule (Ante, 1926)
- 2. Reserve capacity rule (Smith, 1961)
- 3. Mesiodistal width of cusp rule (Reynolds, 1968)

Clinical Prognosis

Environmental and Anatomic Factors

In a series of long-term studies (5–14 years), McGuire (1991) and McGuire and Nunn (1996a, 1996b, 1999) attempted to determine if it was possible to predict the long-term prognosis (Table 1-3) of individual teeth based on the commonly taught clinical criteria listed in Table 1-2.

Their findings were as follows:

- 1. Projections using commonly taught clinical parameters were ineffective in predicting long-term prognosis.
- 2. Projections for posterior teeth were of little or no value.
- 3. Prognosis tended to be more accurate for single rooted teeth and for assigning a good prognosis than a less than good prognosis.
- 4. When the good teeth were excluded, the ability to determine prognosis was 50% at 5 years

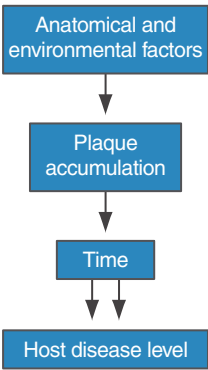


FIGURE 1-3. Continuous theory.

- and 35% at 8 years. This is consistent with the findings of Ghiai and Bissada (1994).
- 5. Teeth with a questionable to poor prognosis have a significantly less favorable survival rate.

McGuire and Nunn (1996a) concluded: “A coin toss would be an easier and more accurate way for a clinician to assign a prognosis under traditional guidelines, if the initial prognosis is less than good.”

A review of their work did show a group of clinical parameters that appeared to correlate with initial prognosis and tooth loss (Table 1-4).

Host Factors

The random burst theory led to our modern concept that disease progression is unpredictable in quality, quantity, and time of progression (Brown and Löe, 1993). Furthermore, the quantity (level of plaque control) and quality (nature and infectibility of the bacteria present) of plaque and environmental or anatomic factors could not solely explain disease variabilities when different risk factors were evaluated (Newman and colleagues, 1994). This was consistent with Löe and colleagues (1986), who found that individual disease progression was marked by wide variations and a lack of predictability.

Genotyping Interleukin-1. Kornman and colleagues (1997) felt that although bacteria were essential for periodontal disease production, there was currently no mechanism for determining the clinical trajectory of the disease. It was clear to them (Kornman and colleagues, 2000) that although bacteria did not directly destroy the bone or connective tissue, indirectly, they activated an inflammatory process in the periodontal tissue that did. The bacteria initiated a challenge, which was then modified by a combination of genetic and acquired (eg, smoking, diabetes) risk factors that amplified the response (Figure 1-4).

Kornman and colleagues (1997) studied the proinflammatory cytokines by identifying the polymorphic interleukin-1 (IL-1) gene cluster. IL-1, produced by the white blood cells, is a key mediator of the inflammatory process and a regulator of prostaglandin E₂ and matrix metalloproteinases, which, respectively, govern inflammation and the destruction of bone and connective tissue. They showed that the composite gene was present in 78% of cases (age 40–60 years), with an 18.9 odds ratio over mild cases, and that IL-1-positive patients and smokers accounted for 86% of the severe cases (Figures 1-5 and 1-6).

This was consistent with Packhill and colleagues (2000), who found that smokers testing positive displayed a 4.9 times higher risk of developing severe periodontitis than did smokers testing negative.

Kornman and colleagues concluded: “This study demonstrates that specific gene markers, that have been associated with increased IL-1 production, are a strong indicator of susceptibility to severe periodontitis in adults” (Figure 1-7).

A number of other studies have shown IL-1 to be positively associated with bone loss and disease progression (Masada and colleagues, 1990; Stashenko and colleagues, 1991; Wilton and colleagues, 1992; Feldner and colleagues, 1994). More recently, Cavanaugh and colleagues (1998) showed a direct relationship between increased crevicular fluid level and more severe bone loss.

Table 1-3 Definitions of Various Prognoses
<i>Good prognosis</i> (one or more of the following): control of the etiologic factors and adequate periodontal support as measured clinically and radiographically to ensure that the tooth would be relatively easy to maintain by the patient and clinician, assuming proper maintenance
<i>Fair prognosis</i> (one or more of the following): approximately 25% attachment loss as measured clinically and radiographically and/or Class I furcation involvement. The location and depth of the furcation would allow proper maintenance with good patient compliance.
<i>Questionable prognosis</i> (one or more of the following): 50% attachment loss with Class II furcations. The location and depth of the furcations may limit proper maintenance.
<i>Poor prognosis</i> (one or more of the following): greater than 50% attachment loss resulting in a poor crown-to-root ratio; poor root form; Class II furcations not easily accessible to maintenance of Class III furcations; 2+ mobility or greater; significant root proximity
<i>Hopeless prognosis</i> : inadequate attachments to maintain the tooth; extraction performed or suggested
Adapted from McGuire and Nunn (1996).

Table 1-4 Clinical Parameters
Mobility*†
Furcation involvement (severe)†
Probing depth†
Unfavorable crown-to-root ratio
Percent bone loss*†
Parafunctional habit without a night guard
Malposed tooth
Smoking
Plaque control (compromised teeth tend not to get worse under maintenance)*†
*Consistent with Ghiai and Bissada (1994).
†Consistent with Nieri and colleagues (2002).

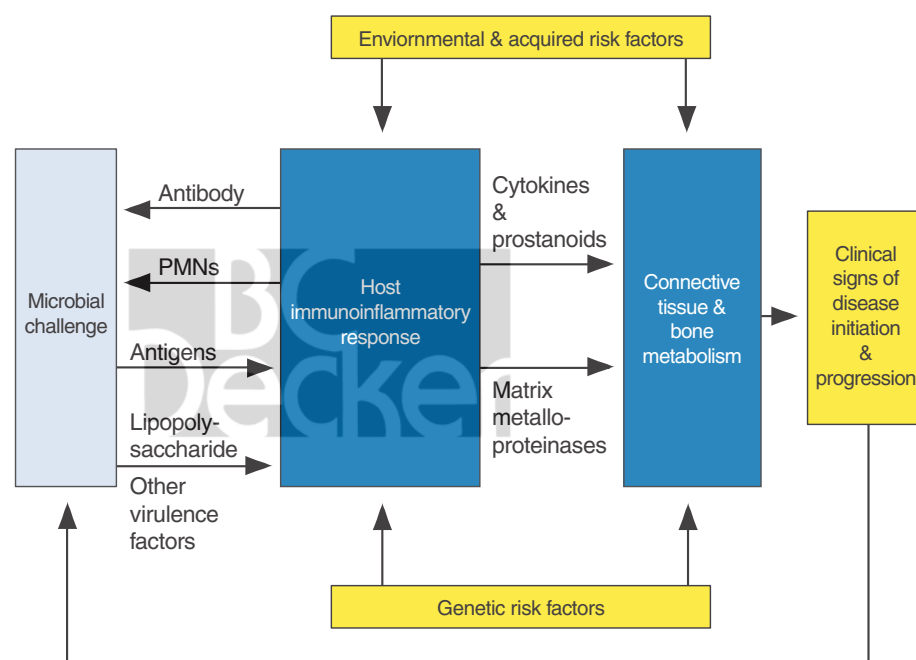


FIGURE 1-4. The pathogenesis of human periodontitis. PMNs: Polymorphonuclear lymphocytes. Contributed by Dr. K Kornman. (Reprinted with permission of Munksgaard, Copenhagen, Denmark)

Lang and colleagues (2000) also showed that IL-1-positive patients are more likely to have a higher frequency of bleeding on probing. Socransky and colleagues (2000) compared the subgingival microbial species on IL-1-positive and -negative subjects. They found that IL-1-positive subjects had higher mean counts of specifically related periodontal pathogens than IL-1-negative subjects.

Clinical Prognosis versus Host Genotype. In 1999, McGuire and Nunn reevaluated 42 of their subjects who had been maintained for 14 years for the IL-1 genotype. They noted that clinical parameters could not identify IL-1-positive

patients and that there was no correlation to family history. Using tooth loss as an indicator of disease progression and advanced disease, they reported a total tooth loss of 4.5% (47 of 1,044 teeth), with 27 (57.5%) teeth being in IL-1-positive patients, who represented only 38% of the patients. McGuire and Nunn's findings appear in Table 1-5.

DeSanctis and Zuchelli (1999) studied regeneration in IL-1-positive and IL-1-negative patients. They found that although the regenerated tissue was stable over 4 years in IL-1-negative patients, the *IL-1-positive patients lost up to 70% of the regenerated tissue.*

Axelson (2002), in a randomized 10-year analytic study of 283 50-year-old subjects, studied the role of genetic IL-1 polymorphism on tooth and alveolar bone loss. All patients were treated periodontally and received regular periodontal maintenance. A PST® (Genetic Test for Susceptibility to Periodontal Disease, Kimball Genetics, Denver, Colorado) for genetic IL-1 polymorphism was administered to all subjects at the conclusion of the study. The findings shown in Table 1-6 were of significance (Figures 1-8 and 1-9):

Thus, genetic polymorphism and smoking appear to be synergistic prognostic risk factors, which is consistent with the findings of Kornman (1997, 2002), Hart and Kornman (1997), McGuire and Nunn (1999), and Meisel and colleagues (2004) for tooth and attachment loss and Nieri and colleagues (2002) for bone loss.

Nieri and colleagues (2002), in a 10-year study of prognosis involving 60 (40–58 years old) nonsmoking IL-1-positive (23 or 38.3%) and IL-1-negative (37 or 61.7%) moderately to severely involved periodontally treated and maintained subjects (1,566 teeth), found the following:

1. There is a total tooth loss of 3.3% (52 of 1,566) owing to a combination of selection and a high level of periodontal maintenance.
2. A prognostic relationship exists between initial bone level and genotype.
3. Some clinical factors do correlate significantly with tooth loss in nonsmokers:
 - a. Mobility
 - b. Deep initial probing
 - c. Initial bone level (loss)
 - d. Plaque control
 - e. Depth of the infrabony defect

Nieri and colleagues (2002) stated: ***“Anything that increases mobility decreases prognosis.”***

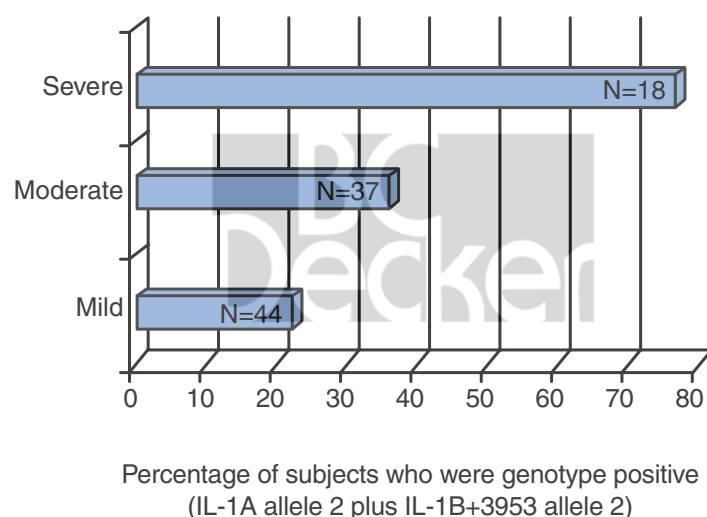


FIGURE 1-5. The occurrence of the composite genotype for nonsmokers in different disease groups. (Adapted from K Kornman et al. J Clinical Periodontology 1997)

Cumulative % of subjects with $\geq 30\%$ mean bone loss

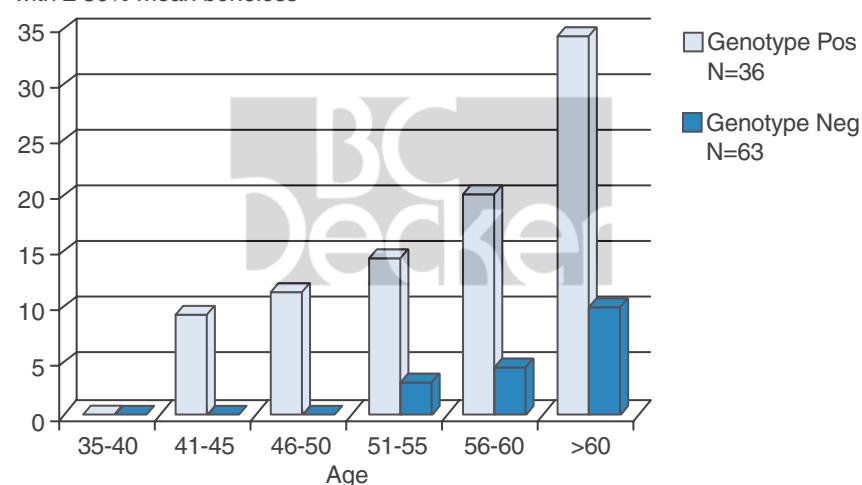


FIGURE 1-6. The cumulative frequency distribution of nonsmokers with severe bone loss ($\geq 30\%$) at different age groups. (Adapted from Kornman et al, J Clinical Periodontology, 1997)

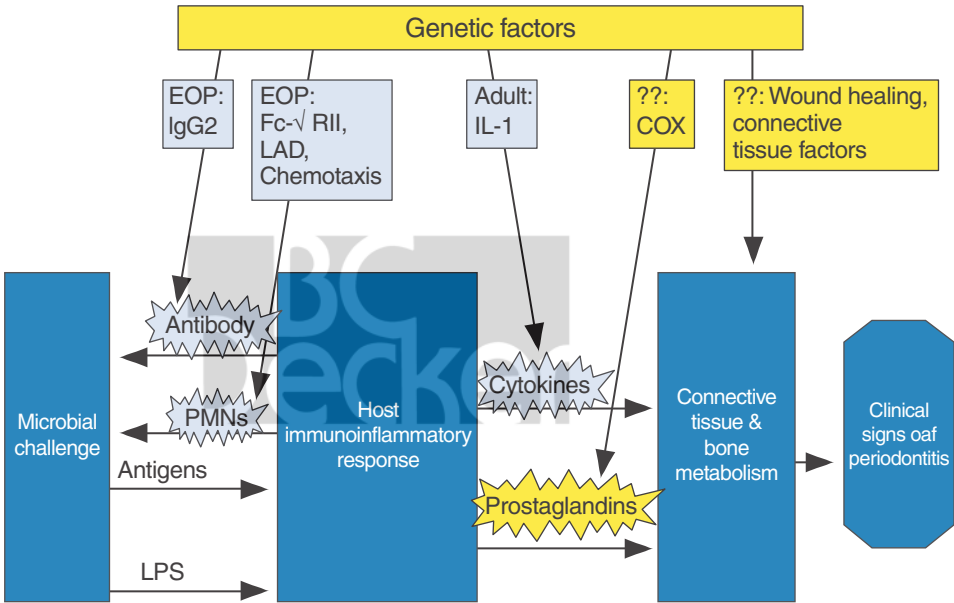


FIGURE 1-7. Genetic factors in periodontitis and their potential biologic influence. Shown in red are candidate genetic factors for which there are current data to support a role in periodontitis. Shown in yellow are candidate genetic factors for which there are data to support a role for the biochemical factors in periodontitis, but for which there are no current data associating a specific genetic marker with disease (Reprinted from K Kornman, editor. Periodontology 2000 with permission of Munksgaard, Copenhagen, Denmark).

IL-1 genetic testing is available from Kimball Genetics and is called PST® (Genetic Test for Susceptibility to Periodontal Disease). It has been recommended in the following cases:

- 1. Patients with advanced periodontal disease requiring
 - a. Regeneration
 - b. Advanced prosthetics
- 2. Smokers with advanced periodontitis who want implants
- 3. Smokers with advanced periodontitis
- 4. Retreatment of recurrent periodontitis
- 5. Establishing proper maintenance intervals

Note: It is important to point out that although Greenstein and Hart (2002) and the American Academy of Periodontology Research, Science and Therapy Committee (2005) concluded that there is currently an insufficient body of evidence to support a modification of treatment protocols for chronic periodontitis patients based on IL-1 testing, there is enough evidence to recommend testing in patients who smoke and have untreated advanced periodontal disease so that a more accurate long-term prognosis can be made if the patient were not to have treatment or if plaque control were not to be maintained.

Trauma from Occlusion

Occlusal trauma (Figure 1-10) was originally considered a primary etiologic factor in the progress of periodontal disease (Stillman, 1917; Box, 1935). Once the actual pathogenesis of periodontal disease was determined (Löe and colleagues,

1965), the theory of trauma from occlusion as a codestructive factor of disease progression was advocated by Glickman and Smulow (1962, 1965, 1967). This theory was based on the concept that once bacteria initiate the disease process, trauma from occlusion altered the pathway of inflammation, resulting in a greater destruction of the periodontal supporting structures (bone and periodontal ligament) (Figure 1-11).

Animal research in the beagle (Svanberg, 1974; Linane and Ericsson, 1976; Lindhe and Svanberg, 1976) and the squirrel monkey (Polson, 1974; Kantor and colleagues, 1976; Polson and colleagues, 1976) did not resolve the issue of the legitimacy of trauma from occlusion. The proceedings

Table 1-5 Clinical Prognosis versus Host Genotype	
Probability of Tooth Loss	Risk Ratio
Genotype (IL-1) positive	2.7
Heavy smokers	2.9
IL-1 positive/smoking	7.7
IL-1 positive (nonsmokers): clinical risk factors	
Mobility	8.8
Unfavorable crown-to-root ratio	9.2
Bone loss	6.2
Probing depth	3.6
Furcations	3.2
Mobility, unfavorable crown-to-root ratio, and bone loss possess equal or greater predictability than the combination of smoking and IL-1 positive factors and should therefore be considered significant.	

of the World Workshop in Clinical Periodontics (1989) summed it up best, stating that the relationship between periodontal disease and occlusion was controversial and that there was no long-term evidence of the effectiveness of occlusal adjustment as a treatment for periodontal disease.

In 1992, Burgett and colleagues published a significant human study on the effects of occlusal adjustment on treated type IV periodontal cases. They reported that occlusal adjustment resulted in a significant increase in clinical attachment levels over those not receiving occlusal adjustment. They offered no explanation and said that further study was required. Wang and colleagues (1994) found that molars with furcation involvement were 2.5 times more likely to be lost and that mobility increased this tendency. Gilbert and colleagues (2005) found that teeth classified as mobile at baseline “were more likely to have experienced attachment loss incidence than those not mobile at baseline.”

At the World Workshop in Periodontics (1996), Gehr noted that “the articles clearly demonstrate that occlusal forces are transmitted to the periodontal attachment apparatus and those forces can cause changes in the bone and connective tissue. These changes can effect tooth mobility and clinical probing depth.” Wang and colleagues (1994) showed that mobility resulted in attachment loss.

In 2001, Nunn and Harrel published their classic “clinical” articles on the effects of occlusal discrepancies (ODs) on periodontitis. Unlike other studies that looked at the overall general effects of trauma from occlusion on disease progression (Shefter and McFall, 1984; Philstrom and colleagues, 1986; Cao, 1992), Harrel and Nunn looked at the effects of occlusion on the progression of periodontal disease on individual teeth (2,147) in treated (41), partially treated (18), and untreated (30) patients. Their results were divided into initial and post-treatment findings.

A. Initial findings

In comparing teeth with ODs versus no occlusal discrepancies (NODs), they found that teeth with ODs had significantly

- 1. Deeper initial probing
- 2. Worse initial prognosis
 - a. OD was fair
 - b. NOD was fair to good
 - c. Greater mobility

Table 1-6 Role of Genetic IL-1 Polymorphism on Tooth and Alveolar Bone Loss		
Subject	Tooth Loss	Bone Loss (mm)
PST- nonsmoker	0.16	0.26
PST+ nonsmoker	0.30	0.33
PST- smoker	0.43	0.55
PST+ smoker	0.95	1.20
Mean tooth loss	0.40	

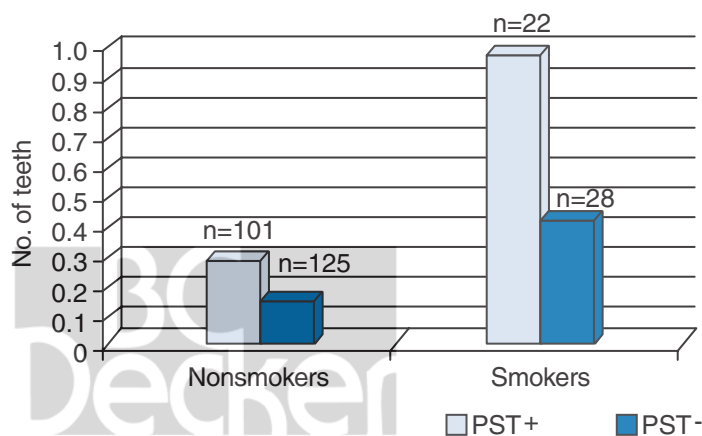


FIGURE 1-8. The mean number of lost teeth per subject per 10 years in smokers and nonsmokers testing positive (PST+) negative (PST-) for genetic polymorphism of interleukin. (Adapted from Ayelson et al. Diagnosis and Risk Prediction of Periodontal Disease, 2002. Quintessence, Illinois)

They also found

1. No relationship to furcation involvement
2. In patients with good oral hygiene, OD was the only significant predictor of increased probing depth and initial unfavorable prognosis.
3. Although cofactors such as smoking (increased pocketing), gender (men had deeper probing depths than women), and oral hygiene (patients with good hygiene had less probing depth than patients with poor hygiene) had an impact, there was no “casual pathway” (Kornman and colleagues, 1997; McGuire and Nunn, 1999) and patients with OD still had a 1 mm greater probing depth.

B. Post-treatment findings

Teeth with OD had significantly greater

1. Likelihood of a worsening prognosis
2. Risk of increased mobility
3. Increase in probing depth (Figures 1-12 and 1-13)

Note: Similar results were seen in patients with good oral hygiene, bringing into question the need for significant etiologic factors for occlusion to have a negative impact.

Harrel and Nunn concluded: “Based on the results obtained in this study, there is evidence that untreated occlusal trauma is certainly a catalyst for the progression of periodontal disease.”

Harrel (2003) noted that occlusion should be considered a cumulative risk factor, similar to smoking, that should be (Hallmon and Harrel 2004) part of routine periodontal treatment.

Modifying Factors

Anterior Esthetics. The modern periodontal paradigm is predicated on papillary preservation maintainable on gingival esthetics and the inter-relationship of the lip, gingival, and occlusal lines. Therefore in the esthetic zone, the clinician must first evaluate all treatments on two primary con-

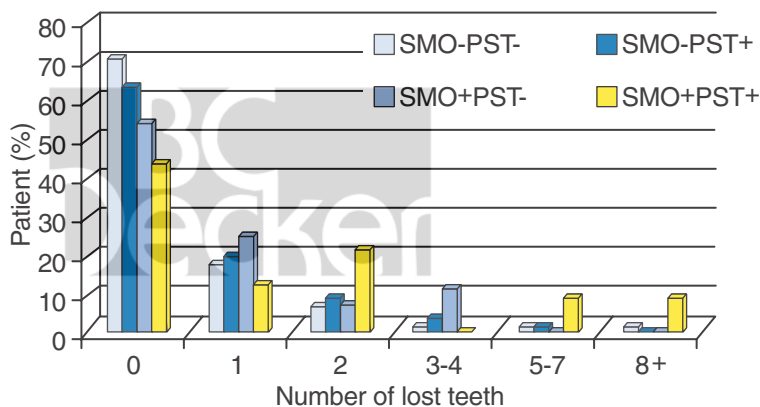


FIGURE 1-9. Frequency distribution of lost teeth in nonsmokers testing positive (SMO-PST+), smokers testing negative (SMO+PST-) and smokers testing positive (SMO+PST+) for genetic polymorphism of interleukin-1. (Adapted from Ayelson et al. Diagnosis and Risk Prediction of Periodontal Disease, 2002. Quintessence, Illinois)

siderations: esthetics and patient’s desires. This is irrespective of prognosis.

Age. Although age, in and of itself, does not affect the individual prognosis, it is still one of its most significant determinates. Younger patients, although possibly possessing greater adaptability and regenerative function, must retain their teeth significantly longer than older patients. The periodontal destruction observed in the elderly is one of lifetime disease accumulation and not an age-specific condition (American Academy of Periodontology, 1995). This disease accumulation provides us with a longer history of their

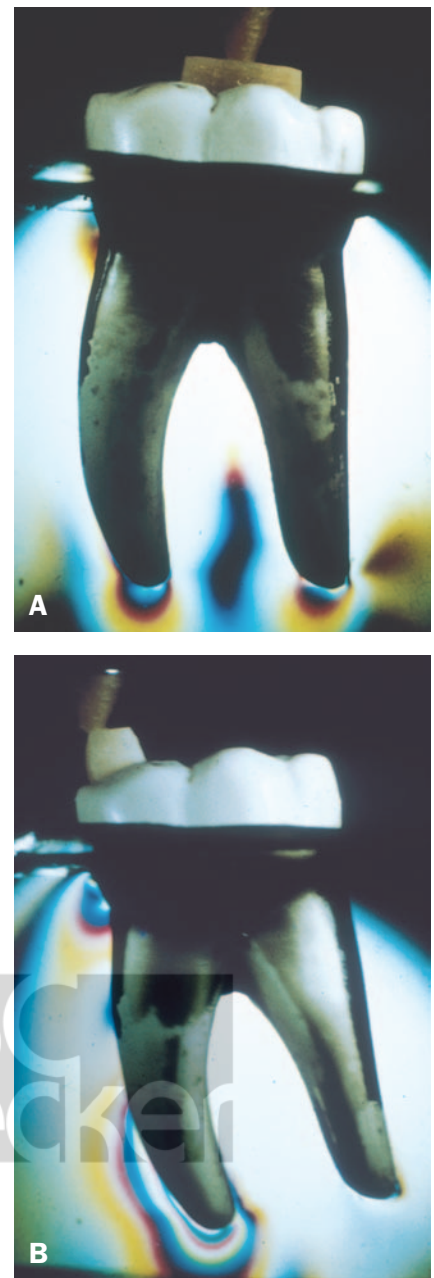
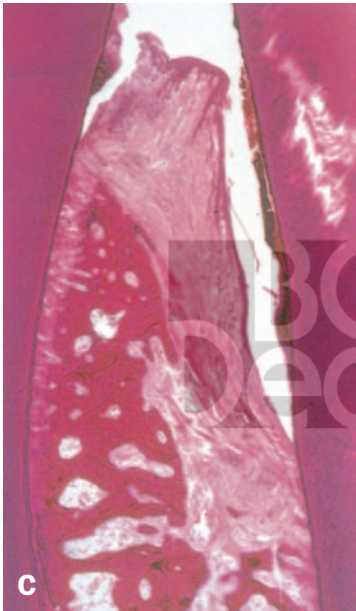


FIGURE 1-10. Silastic model displaying, A, Even force distribution of force applied in long axis of tooth; B, Uneven cervical and apical distribution of forces when an angular force is applied. (Courtesy of Dr. Irving Glickman.)



FIGURE 1-11. Glickman trauma from occlusion. A, Radiograph of cadaver jaw showing intrabony defects. B, Histologic section showing angular bone loss. C, High magnification showing extension of inflammation into tissue. D, Showing destruction of transeptal fibers. (Courtesy of Dr. Irving Glickman.)



periodontal, functional, and restorative status, offering greater diagnostic insight and thus enhancing our ability to determine or predict how their teeth may continue to function in the future. What might not be acceptable in a young person might be acceptable in an older patient.

Motivation, Cooperation, and Level of Plaque Control. *Plaque control is the single most important factor in the treatment of periodontal disease.* The long-term success of any case is predicated on a patient's ability to maintain an adequate level of plaque control. This is even more so in advanced periodontal prosthetic cases. Complex advanced periodontal and or prosthetic cases require a highly motivated and cooperative patient for successful resolution. Plaque control, motivation, and cooperation must therefore be carefully evaluated prior to starting (Becker and

colleagues, 1984; Neuman and colleagues, 1994; Nieri and colleagues, 2002).

Clinical Skill Level and Knowledge. Modern periodontal therapy has become a highly complex specialty requiring a diversity of skills, which come only with time, experience, continuing education, and personal application. It is difficult to be an expert in all phases of therapy. Our personal skill limitations should not restrict our patients' treatment options or their success. We must therefore recognize our limitations and refer our patients to someone who possesses a greater degree of competence in a particular area.

Risk of Treatment

Barkman and Kois (2005) stated that the risk of treatment must be determined and combined

with the prognosis for proper triage. They break down their diagnostic parameters for risk and prognosis assessment into the following:

- 1. Periodontal
- 2. Biomechanical
 - a. Caries susceptibility
 - b. Extent of structural compromise
- 3. Functional
 - a. Temporomandibular joint disorders
 - b. Mobility
- 4. Dentofacial

Dentofacial risk is based on the degree of tooth display and our ability to achieve ideal tooth position in relationship to the face.

Note: Barkman and Kois (2005) make the point that as the risk of treatment increases and prognosis decreases, treatment begins to move toward implant-supported restorations.

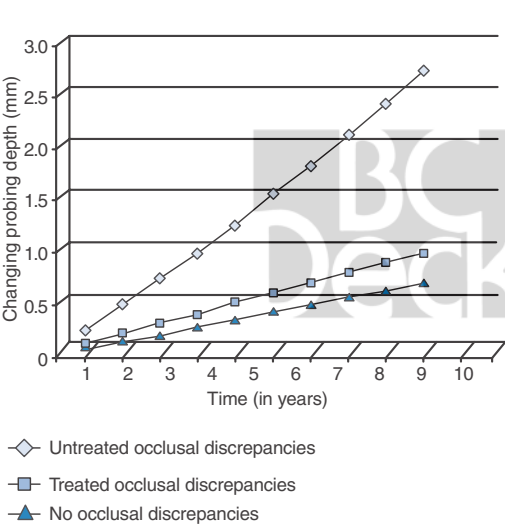


FIGURE 1-12. Change in probing depth over time by occlusal treatment group. (Adapted from Harrel and Nunn, J Perio 2001)

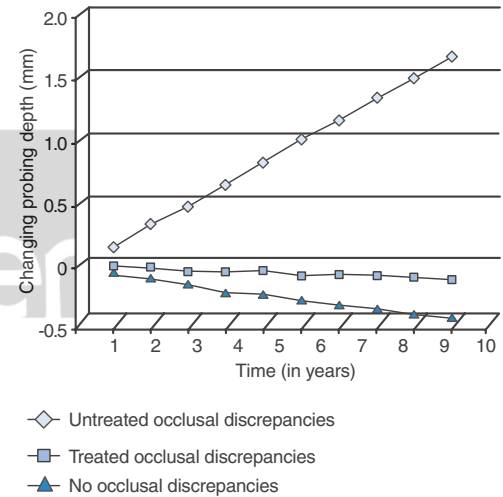


FIGURE 1-13. Change in probing depth over time by occlusal adjustment group for nonsurgical treatment group only. (Adapted from Nunn and Harrell, J Perio 2001)

Summary

- 1. In the presence of smoking, all other clinical factors become secondary (casual pathway) except occlusal discrepancies.
- 2. ODs are one of the most significant local factors.
- 3. Although traditional clinical parameters may not be consistently reliable prognosticators, certain clinical factors, either individually or as a composite group, have been shown to have a higher level of confidence and should be factored in when determining the prognosis:
 - a. Occlusal discrepancies
 - b. Mobility*
 - c. Unfavorable crown-to-root ratio

*Anything that increases mobility decreases prognosis (Nieri, 2002)

- d. Increased probing depth
e. Greater initial bone loss
4. Genotype is a prediction of potential future risk in untreated periodontal cases.
 5. Patients who are IL-1 positive can be treated successfully, be well maintained over the years, and do not require altered treatment modalities.
 6. IL-1-positive smokers should be regarded as potential higher-risk patients, whereas IL-1-negative nonsmokers are considered at low risk of developing tooth loss and bone loss.
 7. Smokers can be treated successfully if they will cease smoking.
 8. In the presence of good plaque control, long-term success is improved and risk factor influence is diminished except when ODs are present.

Note: Kaldahl (1996) studied the relationship between periodontal treatment and smoking and concluded that “while the negative effects of smoking on therapy were sustained or increased over time, it must be remembered that periodontal therapy in all groups produced improvements of all clinical parameters.”

Table 1-7. Periodontal Prognosis Checklist

	Favorable	Unfavorable		Favorable	Unfavorable
HOST FACTORS					
Local factors			3. Initial bone level lost		
1. Genotype			a. 0–25%	√	
a. IL-1 positive (PST+)		√	b. 25–50%	√–	
b. IL-1 negative (PST–)	√		c. 50%		√
2. Smoking			Note: The initial bone level is a greater prognosticator than the residual bone level. Radiographs versus digital images Khocht and colleagues (2003) found that standard radiographs and digital images were not comparable and that digital images “tended to reveal a higher number of sites with early-to-moderate bone loss than did conventional images.”		
a. Nonsmoker	√		4. Crown-to-root ratio		
b. Heavy smoker		√	a. 1:2–1:1.5	√	
3. Parafunction (see also occlusion)			b. 1:1.5–1	√–	
a. With night guard	√		c. 1:1		√
b. Without night guard		√	5. Bone topography (amenable to guided tissue regeneration)		
4. Motivation/cooperation			a. Horizontal bone loss		√
a. Low plaque	√		b. Intrabony defects (2–3 walls)	√	
b. High plaque		√	c. Hemiseptum (1 wall)		√
(Unfavorable) systemic factors			Note: The deeper the intrabony defect, the greater the potential for bone regeneration and the more favorable the prognosis.		
1. “Uncontrolled” systemic disease			6. Furcations		
a. Diabetes			a. No involvement	√	
b. Hyperparathyroidism			b. Grade I	√	
c. Hyperthyroidism			c. Grade II (early)	√–	
2. Nutritional deficiencies			d. Deep grade II and III		√
3. Alcohol and drug abuse			Note: Deep grade II and grade III formations are treatable and maintainable on an individual basis, but hemisection and root amputation may be considered for abutments.		
4. Stress			7. Occlusion		
5. Xerostomia			Note: Increased or increasing mobility has been shown to have a significant negative correlation to prognosis. Therefore, any factor or combination of factors that predisposes a tooth to greater mobility is also significant.		
6. Adverse medications			a. Stable	√	
a. Hydantoin (Dilantin)			b. Unstable (missing teeth; posterior collapse; no incisal guidance; deep overbite; pathologic migration; crowding; centric or balancing side contacts, fractured tooth/teeth, thermal sensitivity; wear facets in conjunction with other indicators)		√
b. Nifedrin/cyclosporine			c. Parafunction without a night guard		√
8. Others			1. Bruxism		√
a. Human immunodeficiency virus (HIV)			2. Clenching		√
b. Neutropenia			d. Fremitus		√
c. Hereditary gingival fibromatosis			e. Primary trauma*	√±1	
TOOTH AND SITE ANATOMIC FACTORS			f. Secondary trauma		√
Primary factors			g. Progressive mobility		√
1. Mobility			Note: If primary occlusal trauma cannot be adequately corrected to reduce mobility, the tooth should be considered questionable.		
a. None	√				
b. +–1	√				
c. 1–1+	√–				
d. 1+–2		√			
Note: Mobility may be the essential element in prognosis. Simply stated, a loose tooth does not make for good long-term prognosis irrespective of the existing attachment levels.					
2. Initial probing depth					
a. 0–3	√				
b. 4–6	√–				
c. 7–10		√			
Note: The greater the initial probing depth, the less favorable the prognosis. Increasing probing is a very negative prognosticator.					

Table 1-7. continued							
		Favorable	Unfavorable			Favorable	Unfavorable
h. Radiographic findings: trauma from occlusion				b. Enamel projections			√
• Crestal one-third widening of the periodontal ligament				c. Root form			
• Thickening of the lamina dura				• Divergent		√	
• Apical widening				• Convergent			√
Note: These radiographic signs are an indication of possible trauma from occlusion, requiring further occlusal examination.				d. Root length			
Secondary factors				• Long		√	
1. Shape of the crown				• Short			√
a. Bell shaped							
b. Ovoid shaped							
2. Root shape							
a. Long-flat				√			
b. Short					√		
c. Conical					√		
d. Curved (dilacerated)					√		
3. Root proximity							
a. Adequate				√			
b. Inadequate					√		
4. Decay							
a. Restorable				√			
b. Nonrestorable					√		
Modifying factors							
• Root amputation				√			
• Hemisection				√			
• Crown lengthening				√			
• Orthodontic extrusion				√			
c. Caries susceptibility							
• Low				√			
• High (<i>A strong indication for implant use.</i>)					√		
5. Molars							
a. Root trunk							
• Long				√			
• Short					√		
</							

Conclusion

It is important to note that of the 2,610 teeth (102 patients) followed in the studies by Nieri and colleagues (2002) and McGuire and Nunn (1999), only 99 were lost (3.8%). Most of these teeth had an original prognosis of poor or hopeless (risk

ratio of 51.9). This means that all of these cases, irrespective of genotype, smoking, and/or clinical parameters, can be successfully treated over a long period of time (10–14 years). In complex periodontal-prosthetic cases involving patients with a positive genotype and/or smokers, only teeth

with a good or good to fair prognosis should be used as abutments and ODs should be eliminated. Finally, it should always be remembered that a highly motivated and cooperative patient can very often overcome many if not all negative factors and that the converse is also true (Table 1-7).

Surgical Basics

Basic Incisions

Periodontal disease is multifaceted in the nature, scope, and types of problems created (eg, mucogingival problems, osseous deformities, gingival enlargement); therefore, many types of treatment exist (Figure 2-1). *There is no one way to approach a single problem or procedure.* Training, ability, philosophy, and objectives ultimately determine final treatment selection. The following is a list of basic surgical incisions.

1. Curettage: The removal of the inner epithelial lining, epithelial attachment, and underlying inflamed connective tissue on the inner aspect of the pocket. This is a closed surgical procedure (Figure 2-2A).
2. Gingivectomy: The excisional removal of tissue for treatment of suprabony pockets. This procedure is indicated where bone loss is horizontal and there is an adequate zone of attached keratinized gingiva (Figure 2-2B).
3. Full-thickness (mucoperiosteal) flap: A flap designed to gain access and visibility for osseous surgery, relocation of the frenulum, maintenance of the attached tissue, and pocket elimination and regeneration procedures. The incision can be sulcular, crestal, or inverse bevel, depending on the amount of attached tissue present (Figure 2-2C).
4. Partial- or split-thickness (mucosal) flap: A flap designed to retain and maintain the periosteal covering over the bone. A sharp or supraperiosteal dissection technique parallel to the bone is used in this procedure. It is indicated mostly in areas of thin bony plates and for mucogingival procedures (Figure 2-2D).
5. Modified full-thickness (mucoperiosteal) flap: A flap for which a first-stage gingivectomy incision is used for pocket reduction or elimination, followed by a secondary inverse-beveled incision to the crest of bone. This technique requires an adequate zone of attached keratinized gingiva and is used primarily on the palate, on enlarged tissue, or in areas in which limited access may prevent a primary inverse-beveled incision (Figure 2-2E).

Tables 2-1 and 2-2 compare the various treatment procedures. These should be used only as a general guide in deciding which technique to use. Table 2-3 is a comparative analysis of the various surgical techniques.

Classification of Surgical Procedures

Correction of Soft Tissue Pockets

Closed Procedures.

1. Curettage
2. Excisional new attachment procedure (ENAP) and modified ENAP
3. Modified Widman flap
4. Apically positioned (repositioned) flap
 - a. Full thickness
 - b. Partial/full thickness
 - c. Partial thickness (supraperiosteal)
5. Palatal flap
 - a. Full thickness
 - b. Partial thickness
6. Distal wedge procedure
 - a. Tuberosity
 - b. Retromolar area

Open Procedures.

1. Gingivectomy
2. Gingivoplasty

Surgery for Correction of Osseous Deformities and Osseous Enhancement Procedures

Closed Procedures.

1. Full- or partial-thickness flap
 - a. Apically positioned flap
 - b. Unpositioned flap
 - c. Modified flap
 - d. Modified Widman flap
2. Distal wedge procedure
3. Palatal flap

Open Procedures.

1. Gingivectomy
 - a. Rotary abrasives
 - b. Interproximal denudation
 - c. Intrabony pocket procedure
2. Prichard procedure for osseous fill

Guided Tissue Regeneration (GTR).

Guided Bone Regeneration (GBR).

Correction of Mucogingival Problems

Preservation of Existing Attached Gingiva.

1. Apically positioned (repositioned) flap
 - a. Full thickness
 - b. Partial thickness
2. Frenectomy or frenotomy
3. Modified Widman flap

Increasing Dimension of Existing Attached Gingiva.

1. Mucosal stripping
2. Periosteal separation
3. Laterally positioned flap (pedicle)
 - a. Full thickness
 - b. Partial thickness
 - c. Periosteally stimulated
 - d. Partial/full thickness
4. Papillary flaps
 - a. Double papillae
 - b. Rotated papillae
 - c. Horizontal papillae
5. Edlan-Mejchar, subperiosteal vestibular extension operation, or double lateral bridging flap
6. Free soft tissue autografts
 - a. Partial thickness
 - b. Full thickness
7. Connective tissue autograft
8. Subepithelial connective tissue graft

Procedures Commonly Used for Root Coverage

Pedicle Flaps (Full or Partial Thickness).

1. Laterally positioned flaps
2. Double-papillae flaps
3. Coronally positioned flaps
4. Periosteally stimulated flaps
5. Semilunar flap
6. Rotated or transpositional pedicle flap

Free Soft Tissue Autografts.

1. Full thickness
2. Partial thickness

Subepithelial Connective Tissue Graft.

Acellular Dermal Matrix Grafts.

Guided Tissue Regeneration.

1. Nonresorbable
2. Resorbable

Procedure Commonly Used for Ridge Augmentation

Connective Tissue Graft.

1. Pouch procedure
2. Connective tissue graft/coronally positioned flap
3. Pediculated connective tissue graft
4. Onlay interpositional graft
5. Interpositional graft

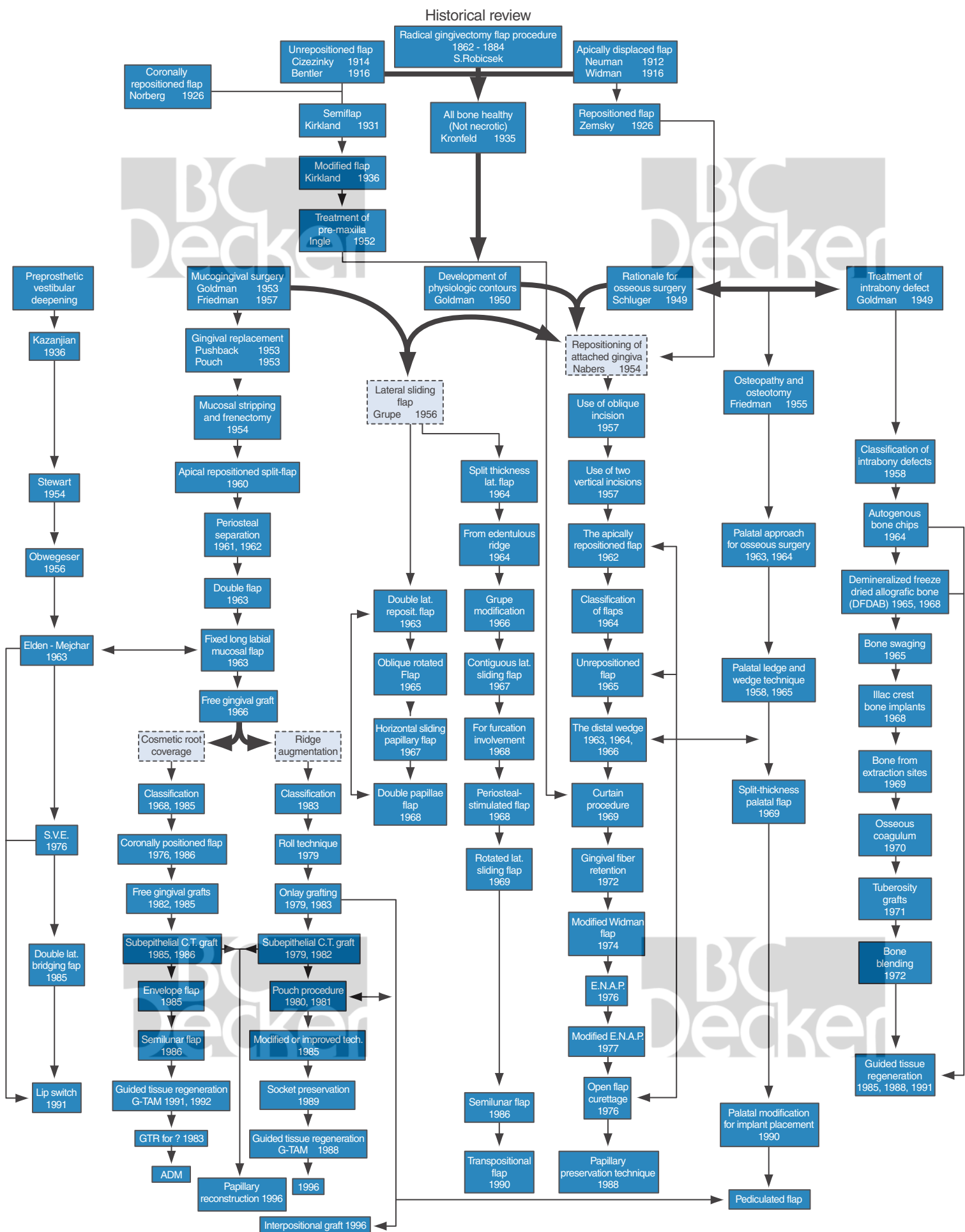


FIGURE 2-1. Historical review.

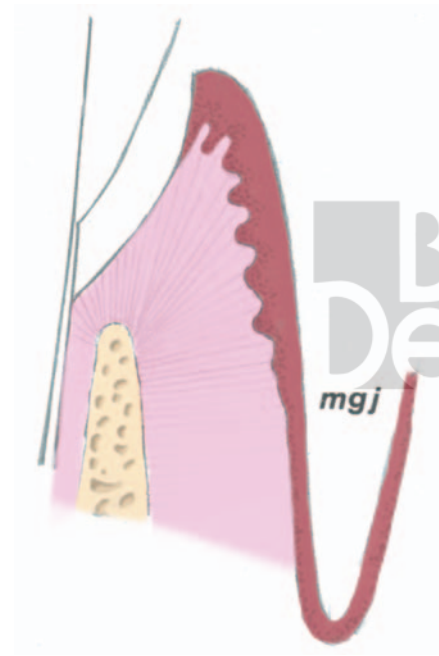
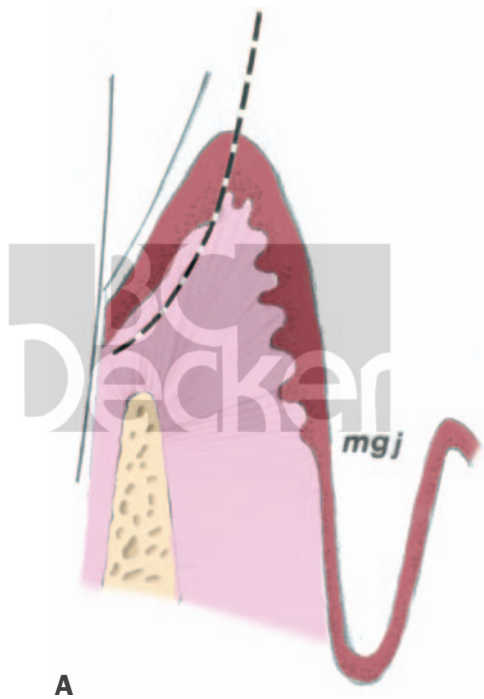


FIGURE 2-2. Outline of basic incisions. A, Curettage incision and removal of an inflamed inner pocket wall. B, Gingivectomy incision and subsequent removal of excised tissue (note that the incision is above the mucogingival junction [mgj]). C, Sulcular (a) and crestal (b) incisions for full-thickness mucoperiosteal flaps. D, Partial-thickness incisions for partial-thickness flaps. E, Modified flap incisions for ledge-and-wedge techniques.

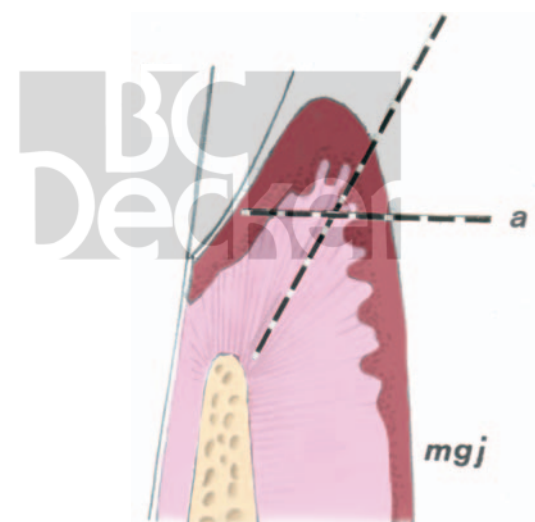
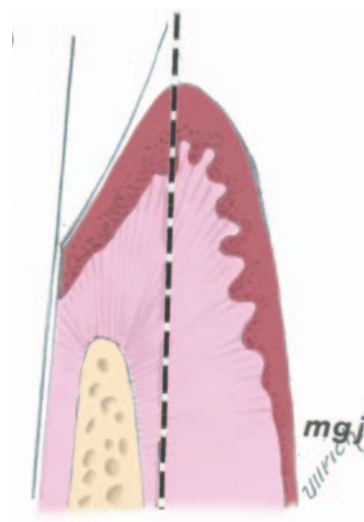
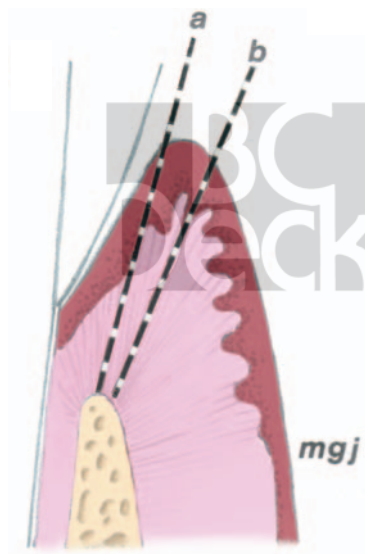
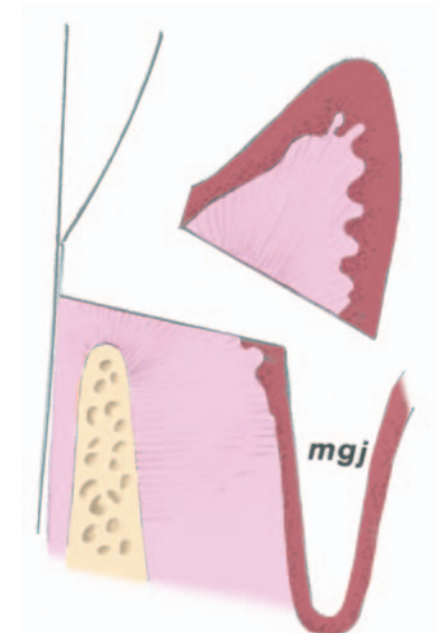
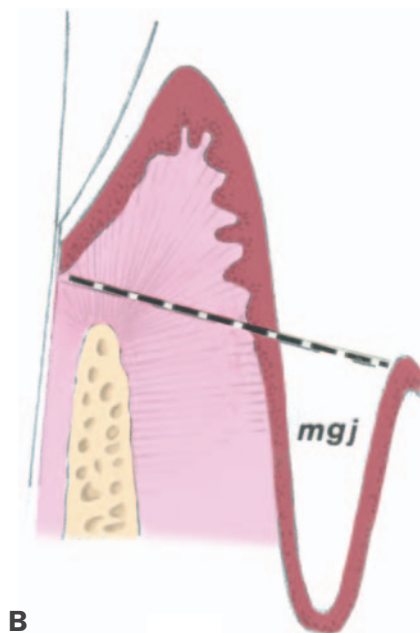


Table 2-1 Comparison of Open (Gingivectomy) versus Closed (Flap) Procedures		
Variables	Open (Gingivectomy)	Closed (Partial- or Full-Thickness Flaps)
Healing	Secondary intention	Primary intention
Time requirement for completion of procedure	Fast	Slower
Reattachment	No	Possible
Degree of difficulty	Low	High
Bleeding postoperatively	Yes	Minimum
Visibility for osseous surgery	Inadequate	Good
Ability to treat irregularities and defects	Inadequate	Good
Preservation of keratinized gingiva	No	Yes

Procedures Commonly Used for Socket Preservation

1. Basic procedure
 - a. Socket filler
 - b. Connective tissue graft
2. Socket seal
3. CollaPlug (Sulzer Medica, Carlsbad, California)
4. Prosthetic support

Procedures Commonly Used for Papillary Reconstruction

1. Connective tissue grafts
2. Bone graft/connective tissue graft

Contraindications for Periodontal Surgery (Lindhe, 2003)

1. Patient cooperation
2. Cardiovascular disease
 - a. Uncontrolled hypertension
 - b. Angina pectoris
 - c. Myocardial infarction
 - d. Anticoagulant therapy
 - e. Rheumatic endocarditis, congenital heart lesions, and heart vascular implants
3. Organ transplants
4. Blood disorders
5. Hormonal disorders
 - a. Uncontrolled diabetes
 - b. Adrenal dysfunction
6. Hematologic disorders
 - a. Multiple sclerosis and Parkinson's disease
 - b. Epilepsy
7. Smoking—more a limiting factor than a contraindication

Note: No periodontal surgery should be undertaken on a medically compromised patient without a recent physical evaluation and clearance by a physician.

General Surgical Considerations

Presurgical Considerations

1. A complete medical history should be taken and any underlying systemic disorders or problems (ie, hypertension, diabetes, or

hemorrhagic disorders) should be under adequate control. Medications should be carefully noted, and medical consultations and preoperative laboratory work should be performed where indicated. It is important to note that the medical history consists of a review of drug abuse, transfusion, and alternative lifestyles in attempting to determine the risk of acquired immune deficiency syndrome (AIDS) or human immunodeficiency virus (HIV). This should be combined with a thorough oral examination (eg, ulcers, candidiasis, hairy leukoplakia). **Note: The best protection against AIDS and hepatitis is a proper barrier technique and sterilization at all times.**

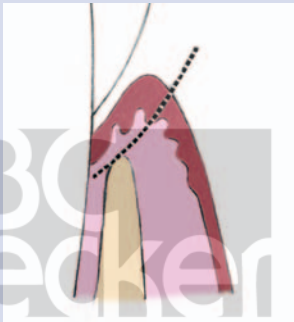
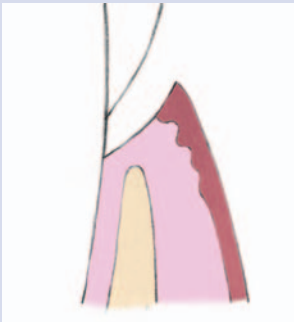
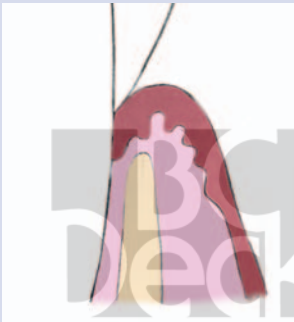
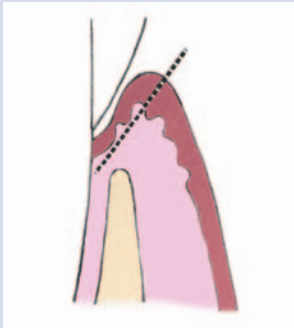

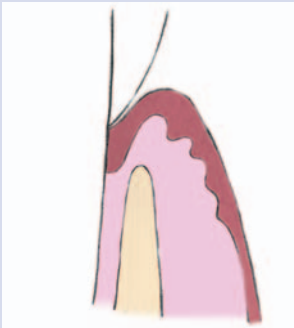
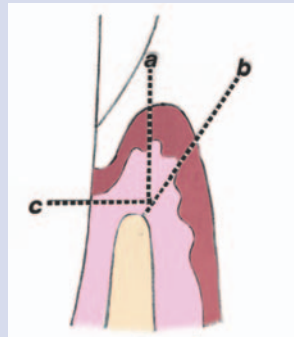
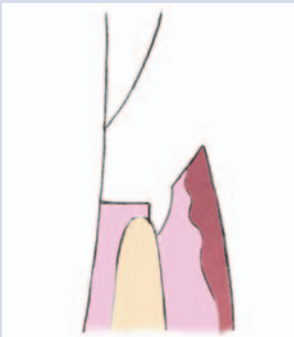
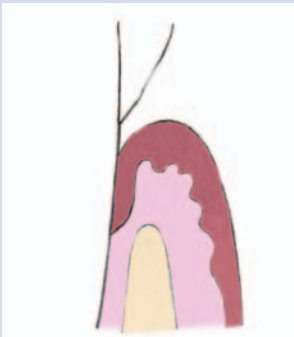
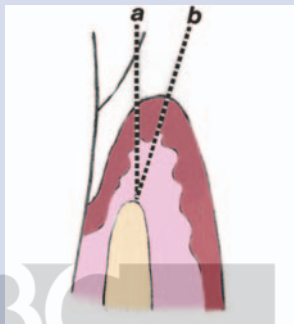

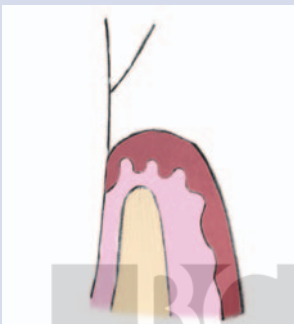
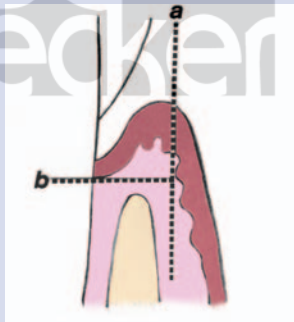
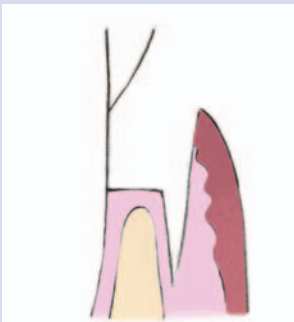
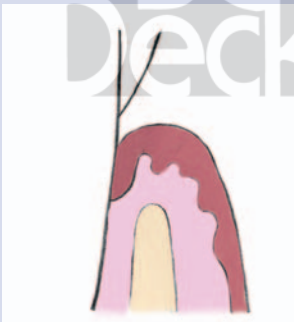
2. Blood pressure should be recorded.
3. Surgical therapy should be considered only after adequate control, scaling, root planing, and all necessary restorative, prosthetic, endodontic, orthodontic, and occlusal stabilization and splinting procedures have been completed and the case has been reevaluated. *Without proper plaque control, there is no need for surgery.*
4. A surgical consent form should be completed in all cases, and periodontal documentation (including tissue quality, pocket depths, radiographs, and models) is a must.

Surgical Considerations

1. Procedural selection should be based on the following:
 - a. Simplicity
 - b. Predictability
 - c. Efficiency
 - d. Mucogingival considerations
 - e. Underlying osseous topography
 - f. Anatomic and physical limitations (eg, small mouth, gagging, mental foramen)
 - g. Age and systemic factors (eg, cardiac arrhythmias and murmurs, diabetes, history of radiation treatment, hypothyroidism, hyperthyroidism)
2. All incisions should be clear, smooth, and denifite. Indecision usually results in an uneven, ragged incision, which requires more healing time.
3. All flaps should be designed for maximum use and retention of keratinized gingival tissue so as to maintain a functional zone of attached keratinized gingiva and prevent needless secondary procedures.
4. The flap design should allow for adequate access and visibility.
5. Involvement of adjacent noninvolved areas should be avoided.
6. The flap design should prevent unnecessary bone exposure, with resultant possible loss and dehiscence or fenestration formation.
7. Where possible, primary intention procedures are preferred to those of secondary intention.
8. The base of a flap should be as wide as the coronal aspect to allow for adequate vascularity.
9. Tissue tags should be removed to allow for rapid healing and prevent regrowth of granulation tissue.
10. Adequate flap stabilization is necessary to prevent displacement, unnecessary bleeding, hematoma formation, bone exposure, and possible infection.

Table 2-2 Comparison of Full- and Partial-Thickness Flaps		
Variables	Full Thickness (Mucoperiosteal)	Partial Thickness (Mucosal)
Healing	Primary intention	Secondary intention
Degree of difficulty	Moderate	High
Pocket elimination	Yes	Yes
Osseous surgery, resective or inductive	Yes	No
Periosteal retention	No	Yes
Relocation of frenum	Yes	Yes
Widen zone of keratinized gingiva	No	Yes
Increase in attached keratinized gingiva	Yes	Yes
Combine with other mucogingival procedures	No	Yes
Suture variability	Low	High
Presence of a thin periodontium—dehiscence or fenestration	No	Yes
Bleeding and tissue trauma	Limited	Greater

Table 2-3 Comparative Analysis of Five Gingival Surgical Procedures

	I	II	III	
Curettage				Scaling and root planing for removal of calculus, plaque, cementum Curettage of inner inflamed wall of pocket
ENAP				Mark pocket with probe Scalloped internal beveled incision to base of pocket Remove incised epithelium and granulation tissue Root plane Position flap and suture to presurgical level
Modified Widman flap				Primary incision 0.5–1 mm from margin to crest of bone Reflect flap 2–3 mm off bone 2° sulcular releasing incision Horizontal 3° incision above crest of bone Remove epithelium and granulation tissue Scale and root plane Reposition flap and suture with interrupted sutures
Apically positioned full-thickness flap				Sulcularly, crestally, or labially positioned inverse beveled incision to bone Flap completed, reflected off bone Flap is apically positioned and sutured
Apically positioned partial-thickness flap				Crestal incision with blade parallel to long axis of tooth Flap raised by sharp dissection Periosteum retained over bone Flap is apically positioned at or below alveolar crest



Sutures and Suturing

Goals

A surgical suture is one that approximates the adjacent cut surfaces or compresses blood vessels to stop bleeding. Suturing is performed to

1. Provide an adequate tension of wound closure without dead space but loose enough to obviate tissue ischemia and necrosis
2. Maintain hemostasis
3. Permit primary-intention healing
4. Provide support for tissue margins until they have healed and the support is no longer needed
5. Reduce postoperative pain
6. Prevent bone exposure resulting in delayed healing and unnecessary resorption
7. Permit proper flap position

Suture Material

Surgical sutures have been used to close wounds since prehistoric times (50,000–30,000 BC) gave us the first written description of their use dating back as early as 4,000 BC (Macht and Krizek, 1978). Many materials have been used throughout the centuries, such as gold, silver, hemp, fascia, hair, linen, and bark. Yet none have provided all of the desired characteristics.

Qualities of the Ideal Suture Material

The following qualities of the ideal suture material are compiled from Postlethwait (1971), Varma and colleagues (1974), and Ethicon (1985):

1. Pliability, for ease of handling
2. Knot security
3. Sterilizability
4. Appropriate elasticity
5. Nonreactivity
6. Adequate tensile strength for wound healing
7. Chemical biodegradability as opposed to foreign body breakdown

With the possible exception of coated Vicryl (Ethicon, Somerville, New Jersey), none of the sutures available today meet these criteria. Table 3-1 lists the various materials—natural, synthetic, absorbable (digested by body enzymes or hydrolyzed), and nonabsorbable—available for periodontal use.

Use

1. Silk and synthetic sutures are employed most often.
2. Gut sutures are used only when retrieval is difficult when securing grafts and in younger patients. The limited physical characteristics of gut sutures do not warrant their routine use.
3. When using gut (plain or chromic) sutures, it is often advantageous to soak the package in warm water for a half-hour and to pull gently but firmly on the suture when opened. This will remove the kinks and straighten the suture. Finally, lubricating the suture lightly with petrolatum or sterile bone wax will prevent brittleness. **Note: This is not necessary with Ethicon sutures.**
4. Monofilament sutures are recommended for bone augmentation procedures to prevent “wicking,” reduce the inflammatory response, and permit longer retention (10–14 days).
5. Gore-Tex (Flagstaff, Arizona) and coated Vicryl sutures are recommended for guided tissue regeneration procedures.

Material Choice

The choice of materials depends on the following:

1. Surgical Procedure
 - a. Plastic procedures

Suture Site	4-0 to 6-0
Needle Size	P-3*
Material	Chromic gut, silk, monofilament
 - b. Regeneration

Suture Site	3-0 to 5-0
Needle Size	P-3; RT-16†
Material	Gore-Tex, Vicryl
 - c. Apically positioned flaps

Suture Site	4-0
Needle Size	J-1; FS2; P-3
Material	silk

*Small needles (P-3) are more difficult to negotiate the posterior interproximal areas.

†Gore-Tex.

- d. Periosteal suturing

Suture Site	4-0 or 5-0
Needle Size	J-1; P-3
Material	silk
- e. Extractions

Suture Site	3-0 or 4-0
Needle Size	FS-2; X-1
Material	silk

2. Biocompatibility‡
3. Clinical experience and preference
4. Quality and thickness of tissue
5. Rate of absorption versus time for tissue healing

Table 3-2 outlines the characteristics and applications of resorbable and nonresorbable sutures.

Note: Because silk is a multifilament material that “wicks,” it is not the material of choice when any sterile materials are used (eg, implants, bone grafts, guided tissue regeneration, or guided bone regeneration) or in the presence of infection (Silverstein and Kurtzman, 2005). The ideal material for these procedures is expanded polytetrafluoroethylene (ePTFE).

Knots and Knot Tying

“Suture security is the ability of the knot and material to maintain tissue approximation during the healing process” (Thacker and colleagues, 1975). Failure is generally the result of untying owing to knot slippage or breakage. Since the knot strength is always less than the tensile strength of the material, when force is applied, the site of disruption is always the knot (Worsfield, 1961; Thacker and colleagues, 1975). This is because shear forces produced in the knot lead to breakage.

Knot slippage or security is a function of the coefficient of friction within the knot (Price, 1948; Hermann, 1971). This is determined by the nature of the material, suture diameter, and type of knot. Monofilament and coated sutures (Teflon, silicon) have a low coefficient of friction and a high degree of slippage; braided and twisted sutures such as uncoated Dacron and catgut

‡These recommendations are not for microsurgical procedures.

Table 3-1 Sutures and Suturing

Suture	Types	Raw Material	Absorption	Suture Tensile Strength	Tissue Reaction	Knot Tensile Strength	Indications	Ease of Handling
Surgical gut	Plain	Collagen from healthy mammals	Digested by body enzymes within 70 d	+(least)	Moderate +++++	+++	Rapidly healing mucosa Avoid suture removal	Absorbable; should not be used where extended approximation of tissues under stress is required
Surgical gut	Chromic	Collagen from healthy mammals treated with chromic salts	Digested by body enzymes within 90 d	+	Moderate but less than plain gut +++++	+++	As above; slower absorption	Should not be used in patients with known sensitivities or allergies to collagen or chromium
Coated Vicryl (polyglactin 910)	Braided Coated	Copolymer of lactide and glycolide coated with polyglactin 370 and calcium stearate	Hydrolysis 56–70 d	+++	Mild ++	++	Subepithelial mucosal surfaces Vessel ligation All types of general closure	+++
Dexon (polyglycolic acid)	Braided Coated	Homopolymer of glycolic acid coated with polaxamer 188	Slow hydrolysis after 60–90 d	+++	Mild ++	++	Subepithelial sutures Mucosal surfaces Vessel ligation	++++
PDS (polydioxanone)	Monofilament Braided	Polyester polymer	Slow hydrolysis 180–210 d	++++	Slight +	++	Absorbable suture with extended wound support	++
Surgical silk	Monofilament Braided	Natural protein fiber of raw silk treated with silicon protein or wax	Usually cannot be found after 2 yr	++	Moderate +++++	+(least)	Mucosal surfaces	++++ Should not be used in patients with known sensitivities or allergies to silk
Nylon Duralon Ethilon	Monofilament	Long-chain aliphatic polymers Nylon 6 or nylon 6.6	Degrades at a rate of 15–20%/yr	+++	Extremely low 0- +	++	Skin closure	++
Nylon Duralon Sugilon	Braided	Polyamide polymer	Degrades at a rate of 15–20%/yr	+++	Extremely low 0- +	++	Skin closure Mucosal surfaces	++++
Polyester Mersilene Dacron Ethibond	Braided	Polyester, Polyethylene, Terephthalate coated with polybutilate	Nonabsorbable	+++	Minimal +	+++	Cardiovascular, plastic, general surgery	+++ None known
Peolene (polypropylene)	Monofilament	Polymer of propylene	Nonabsorbable	+++	Minimal+ transient acute reaction	++	General, plastic, cardiovascular, skin surgery	++
Gore-Tex	Monofilament	Expanded polytetrafluoroethylene (ePTFE)	Nonabsorbable	+++	Extremely low	++	All types of soft tissue approximation and cardiovascular surgery	++++ Not known
Monocryl (poliglecaprone 25)	Monofilament	Poliglecaprone 25 Copolymer of glycolide and caprolactone	Hydrolysis 90–120 d	++++	Minimal +	+++	Soft tissue closure	+++ Absorbable; should not be used where extended approximation of tissues under stress is required

Table 3-2 Characteristics and Applications of Resorbable and Nonresorbable Sutures

Suture Technique	Discipline Used	Tensile Strength Requirements	Type of Needle Recommended	Diameter of Material Recommended	Type of Material Recommended	Recommended Knot	General and Specific Situations Used
Interrupted suture	Periodontology, dental implant and oral surgery	Minimal to moderate	$\frac{3}{8}$ reverse cutting, tapered	4-0	Chromic gut, silk polytetrafluoroethylene (PTFE)	Slip knot	Interproximal suturing
Figure eight suture	Periodontology and dental implant surgery, extraction sites	Minimal to moderate	$\frac{1}{2}$ or $\frac{5}{8}$ reverse cutting, tapered	4-0	Polyester "color" braided, polypropylene, monofilament nylon	Surgeon's knot	Flaps not under tension
					Chromic gut, gut	Slip knot*	
					Polyester "color" braided, polypropylene, monofilament nylon	Surgeon's knot	
Slings suture	Periodontology, dental implant and oral surgery	Moderate	$\frac{3}{8}$ reverse cutting, taper-cut	4-0	Chromic gut, gut, silk, PTFE	Slip knot	Primary lingual of mandibular molar region
Horizontal mattress suture	Dental implant and oral surgery	High	$\frac{3}{8}$ reverse cutting, taper-cut	3-0	Polyglycolic acid (PGA)	Surgeon's knot	Used when a flap has been elevated on only one side Used in anterior mandible or posterior region to resist muscle pull
Vertical mattress suture				4-0	Chromic, gut, silk	Slip knot	Used to resist muscle pull, closely adapt flaps to bone and either teeth or dental implants Can also be used to apically or coronally position flaps
Vertical sling mattress suture	Periodontology, dental implant and oral surgery, especially when performing guided tissue and bone regenerative techniques	High	$\frac{3}{8}$ reverse cutting, taper-cut	3-0	PGA	Surgeon's knot	Used to resist muscle pull, closely adapt flaps to bone and either teeth or dental implants Can also be used to apically or coronally position flaps
					Silk	Slip knot	Used to resist muscle pull, closely adapt flaps to bone and either teeth or dental implants
					PGA	Surgeon's knot	Can also be used to apically or coronally position flaps
Continuous independent sling suture	Periodontology, dental implant and oral surgery	High	$\frac{3}{8}$ reverse cutting, taper-cut	4-0	Silk	Slip knot	Used to resist muscle pull, closely adapt flaps to bone, regenerative barriers, and dental implants, along with maintaining approximation of flap edges
					PGA	Surgeon's knot	Used primarily in edentulous areas such as mandibular anterior or posterior region to resist muscle pull
					Silk	Slip knot	Used often in dental implant and bone augmentation procedures and in hyperplastic/fibrous ridge reduction for denture stability

*Restricted areas such as buccal vestibule maxillary molars or mucogingival surgery (eg, soft tissue grafts). (Silverstein L, 1999)

have greater knot security because of their high coefficient of friction (Taylor, 1938).

It is interesting to note that basic suture silk, although extremely user friendly, is distinctly inferior in terms of strength and knot security compared with other materials (Hermann, 1971). It also shows a high degree of tissue reaction (Postlethwait, 1968; Taylor, 1978), and the addition of wax or silicon to reduce the tissue reaction and prevent wicking further diminishes knot security (Hermann, 1971).

Knot selection is the last of the variables and the one over which surgeons have the most influence. Knot security has been found to vary greatly among clinicians, and even the security of knots tied by the same clinician varies at different times (Hermann, 1971).

A sutured knot has three components (Figure 3-1) (Thacker and colleagues, 1975):

1. The *loop* created by the knot (Figure 3-1A)
2. The *knot* itself, which is composed of a number of tight “throws” (Figure 3-1B); each throw represents a weave of the two strands
3. The *ears*, which are the cut ends of the suture

In Figure 3-2, we see the four knots most commonly used in periodontal surgery. In a study, Thacker (1975) found that the granny knot was the least secure, always requiring more throws or ties to achieve the same knot strength as the square or surgical knot. For materials with a high degree of slippage (monofilament or coated sutures), flat and square throws were recommended, with *all additional throws being squared*. Cutting the ears of the suture too short is contraindicated when slippage is great because the knot will come untied if the slippage exceeds the length of the ears. Loosely tied knots were shown to have the highest degree of slippage, whereas in tight knots, slippage was not a significant factor.

Principles of Suturing

Ethicon (1985) recommends the following principles for knot tying:

1. The completed knot must be tight, firm, and tied so that slippage will not occur.
2. To avoid *wicking of bacteria*, knots should not be placed in incision lines.
3. Knots should be small and the ends cut short (2–3 mm).
4. Avoid excessive tension to finer-gauge materials because breakage may occur.
5. Avoid using a jerking motion, which may break the suture.
6. Avoid crushing or crimping of suture materials by not using hemostats or needle holders on them except on the free end for tying.
7. Do not tie the suture too tightly because tissue necrosis may occur. Knot tension should not produce tissue blanching.

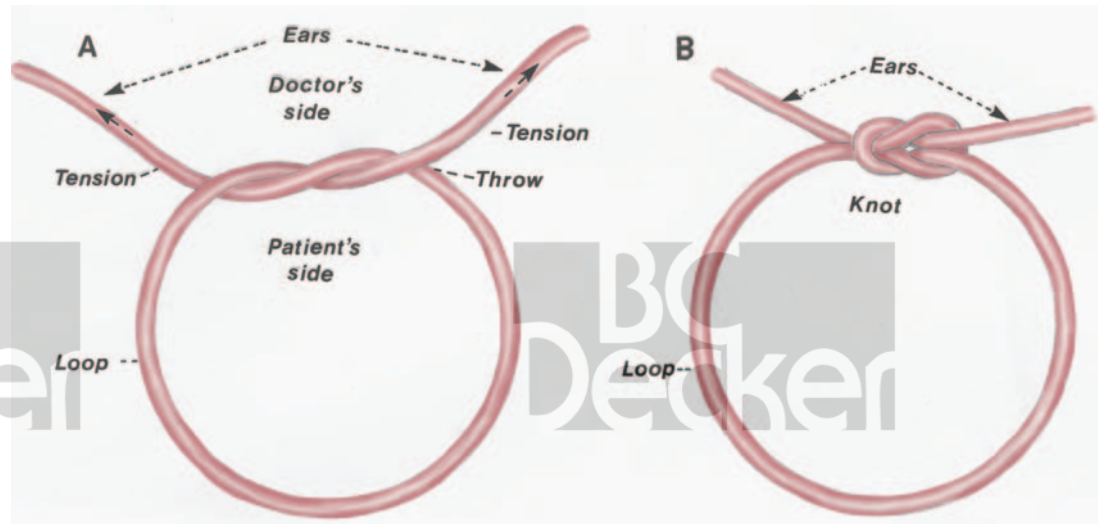


FIGURE 3-1. Knot anatomy. A, Various knot components prior to completion. B, Completed knot anatomy.

8. Maintain adequate traction on one end while tying to avoid loosening the first loop.
9. The surgeons knot and square knot strength, although generally not needing more than two throws, will have increased strength with an additional throw.
10. Granny knots and coated and monofilament sutures require additional throws for knot security and to prevent slippage. Coated Vicryl will hold with four throws—two full square knots.

Sutures should be removed as atraumatically and cleanly as possible. Ethicon (1985) recom-

mends the following principles for suture removal:

1. The area should be swabbed with hydrogen peroxide for removal of encrusted necrotic debris, blood, and serum from about the sutures.
2. A sharp suture scissors should be used to cut the loops of individual or continuous sutures about the teeth. It is often helpful to use a no. 23 explorer to help lift the sutures if they are within the sulcus or in close opposition to the tissue. This will avoid tissue damage and unnecessary pain.

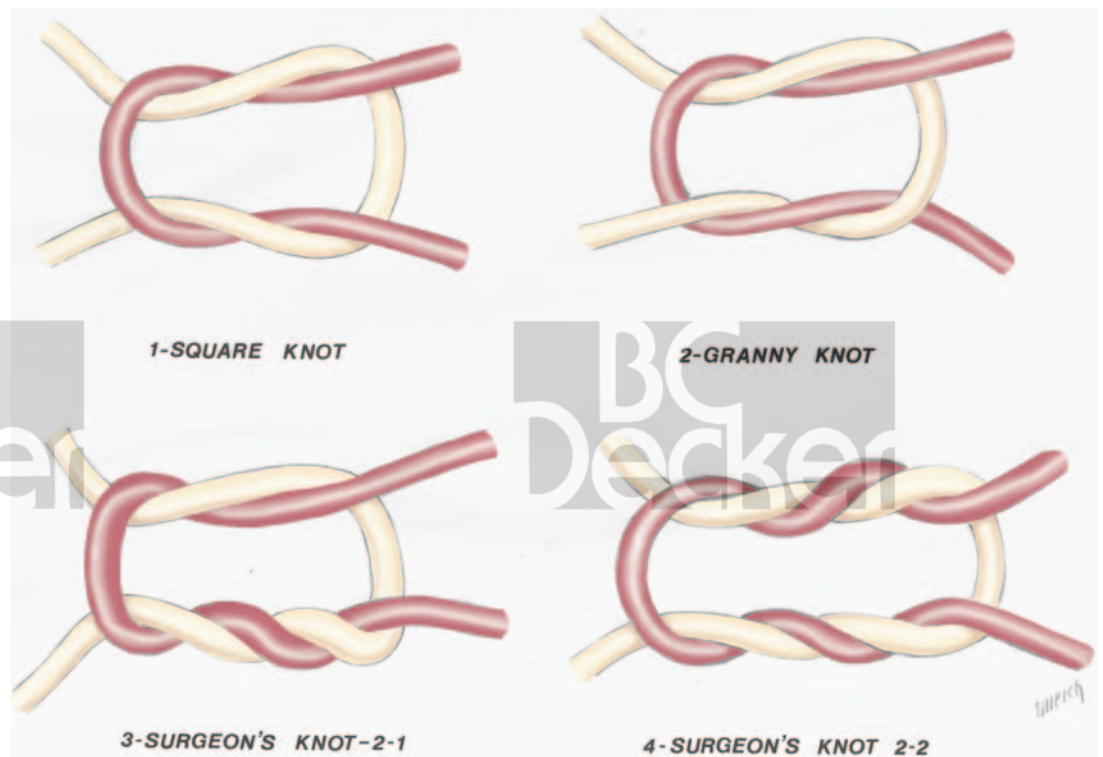


FIGURE 3-2. Suturing knots.

3. A cotton pliers is now used to remove the sutures. The location of the knots should be noted so that they can be removed first. This will prevent unnecessary entrapment under the flap.

Note: Sutures should be removed in 7 to 10 days to prevent epithelialization or wicking about the suture.

Surgical Needles

Most surgical needles are fabricated from heat-treated steel and possess a microsilicon finish to diminish tissue drag and a tip that is extremely sharp and has undergone electropolishing (Ethicon, 1985). The surgical needle has a basic design composed of three parts (Figure 3-3):

1. The eye which is press-fitted or swaged (eyeless) permits the suture and needle to act as a single unit to decrease trauma.
2. The *body* which is the widest point of needle and is also referred to as *the grasping area*. The body comes in a number of shapes (round, oval, rectangular, trapezoid, or side flattened).
3. The point which runs from the tip of the maximum cross-sectional area of the body. The point also comes in a number of different shapes (conventional cutting, reverse cutting, side cutting, taper cut, taper, blunt) (Figure 3-4).
4. The *chord* length is the straight line distance between the point of a curved needle and the swage.
5. The *radius* is the distance measured from the center of the circle to the body of the needle if the curvature of the needle was continued to make a full circle.

Needle Holder Selection

Ethicon (1985) gives the following pointers for selecting a needle holder:

1. Use an approximate size for the given needle. The smaller the needle, the smaller the needle holder required.
2. The needle should be grasped one-quarter to half the distance from the swaged area to the point, as shown in Figure 3-5.
3. The tips of the jaws of the needle holder should meet before the remaining portions of the jaws.
4. The needle should be placed securely in the tips of the jaws and should not rock, twist, or turn.
5. Do not overclose the needle holder. It should close only to the first or second ratchet. This will avoid damaging or notching the needle.
6. Pass the needle holder so that it is always directed by the surgeon's thumb.
7. *Do not use digital pressure on the tissue; this may puncture a glove.*

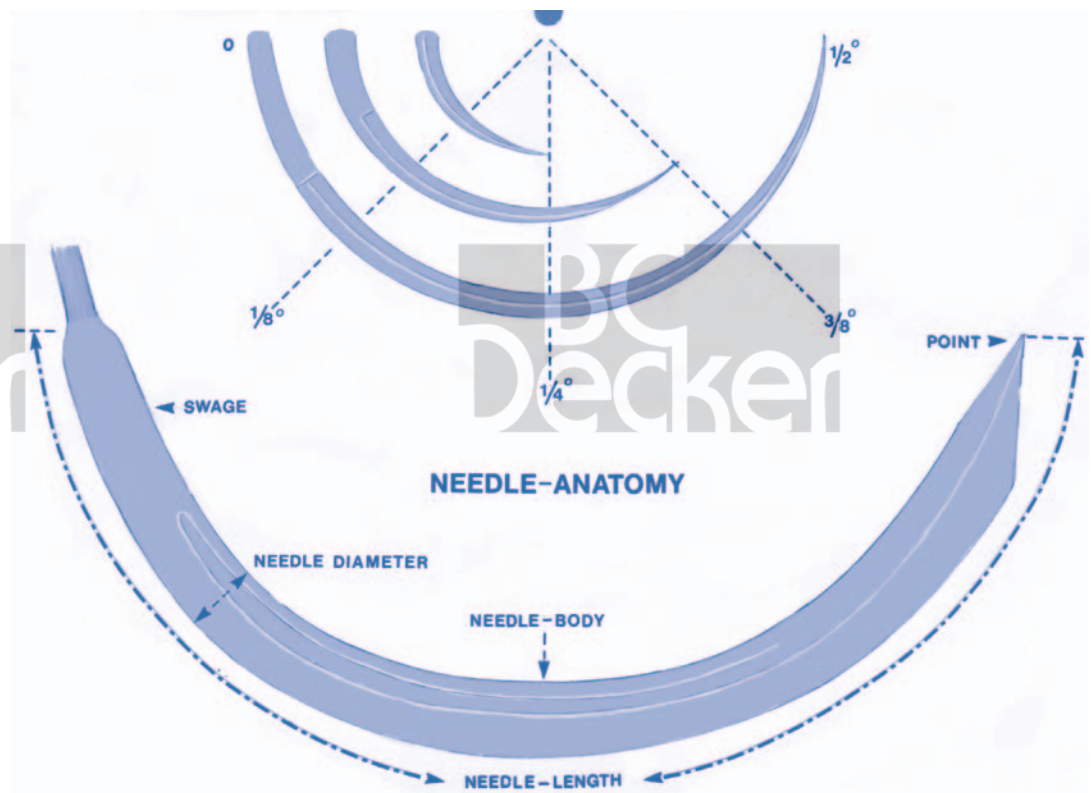


FIGURE 3-3. Needle anatomy. Needles are described by their arc. Most periodontal surgical needles are of three-eighths or one-half curvature. Different components of the needle are described.

Placement of Needle in Tissue

Ethicon (1985) gives the following principles for placing the needle in tissue:

1. Force should always be applied in the direction that follows the curvature of the needle.
2. Suturing should always be from movable to nonmovable tissue.
3. Avoid excessive tissue bites with small needles because it will be difficult to retrieve them.
4. Use only sharp needles with minimal force. Replace dull needles.
5. Grasp the needle in the body one-quarter to half the length from the swaged area. Do not hold the swaged area; this may bend or break the needle. Do not grasp the point area because damage or notching may result (see Figure 3-5).
 - a. Prior to suturing, the needle holder is repositioned to the forward half of the needle with a few millimeters of the tip, as shown in Figure 3-5.
6. The needle should always penetrate the tissue at right angles.
 - a. Never force the needle through the tissue.
7. Avoid retrieving the needle from the tissue by the tip. This will damage or dull the needle. Attempt to grasp the body as far back as possible.
9. An adequate tissue bite ($\geq 2-3$ mm) is required to prevent the flap from tearing.

Suturing Techniques

Different suturing techniques may employ either periosteal or nonperiosteal suture placement:

1. Interrupted
 - a. Figure eight
 - b. Circumferential director loop
 - c. Mattress—vertical or horizontal
 - d. Intrapapillary
2. Continuous
 - a. Papillary sling
 - b. Vertical mattress
 - c. Locking

The choice of technique is generally made on the basis of a combination of the individual operator's preference, educational background, and skill level, as well as surgical requirements.

Periosteal Suturing

Periosteal suturing generally requires a high degree of dexterity in both flap management and suture placement. Small needles (P-3), fine sutures (4-0 to 6-0), and proper needle holders are a basic requirement. Periosteal suturing permits precise flap placement and stabilization.

Technique

The five steps here are used in periosteal suturing (Chaiken, 1977) and are seen in Figure 3-6:

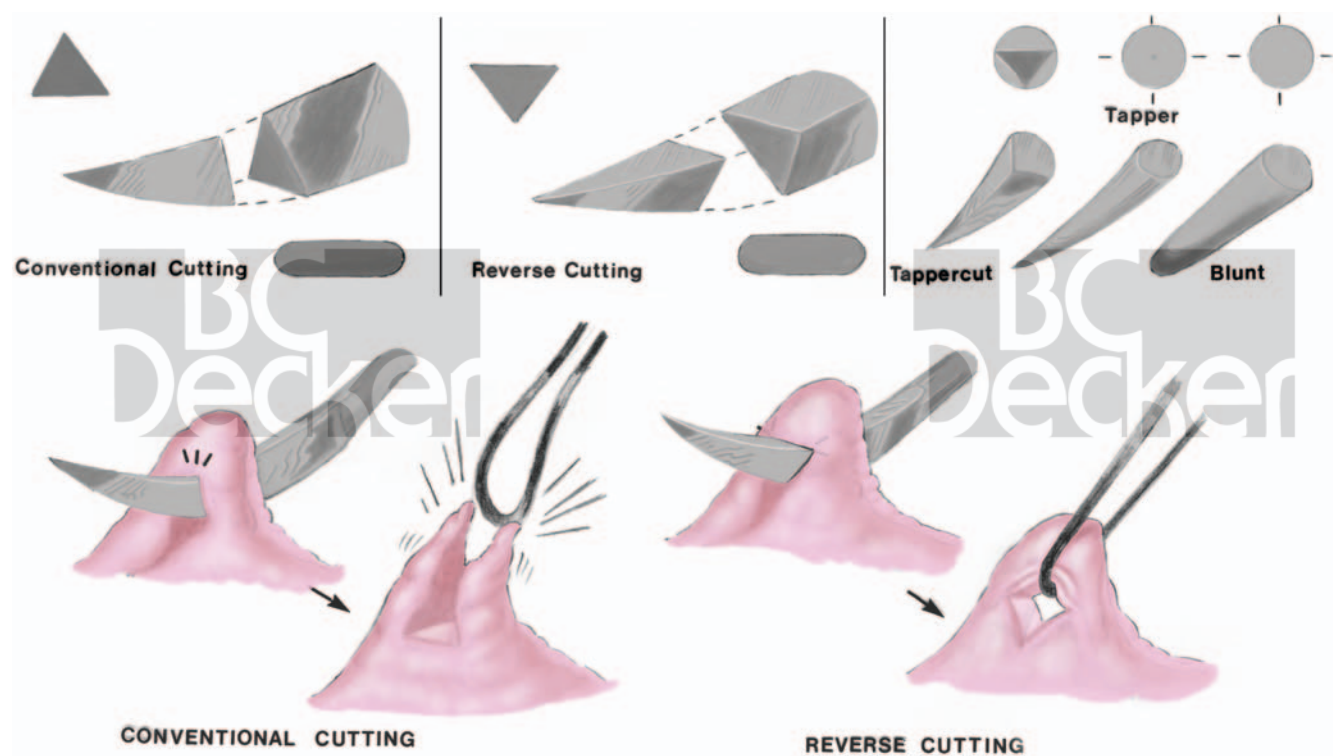


FIGURE 3-4. Cutting needles. Both outline and cross-sectional views of the various forms of cutting needle are shown. Conventional cutting and reverse cutting are also shown.

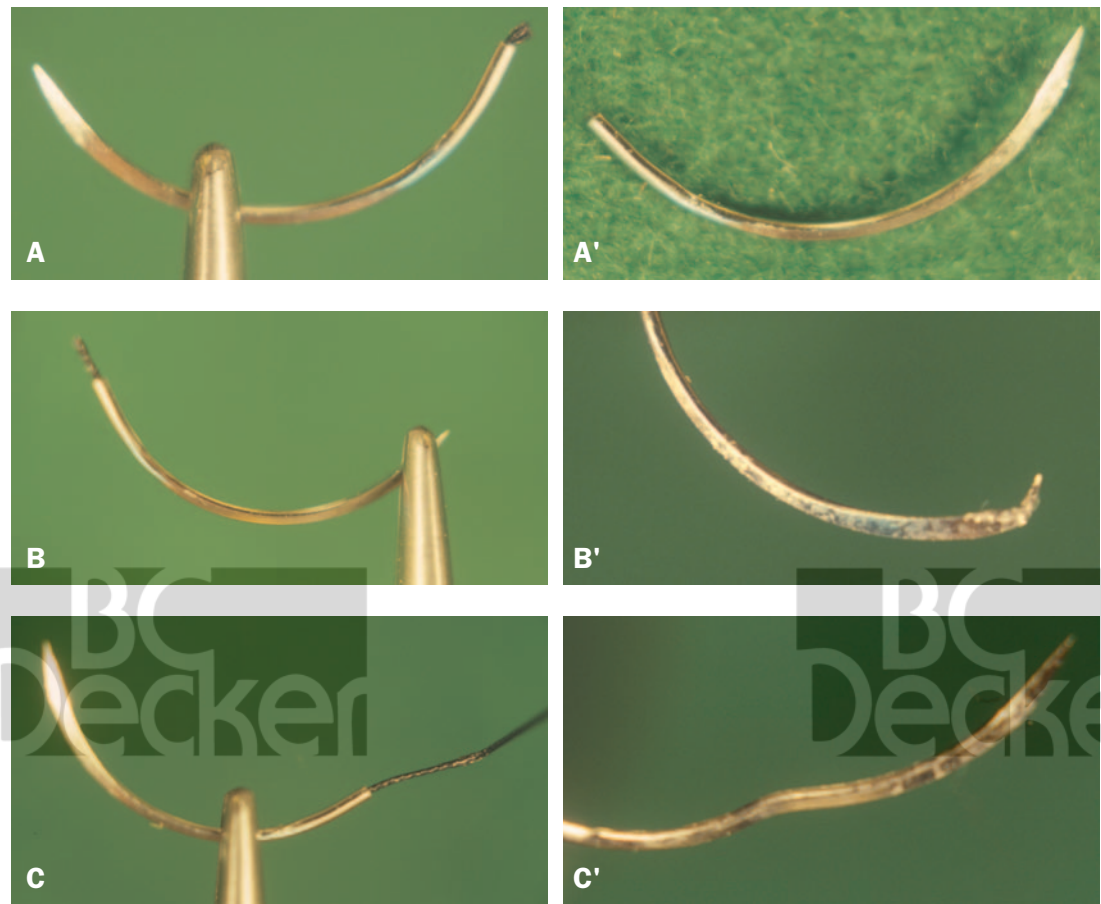


FIGURE 3-5. Correct handling of suture needles. A, Needle holder holding a suture needle just anterior to the curvature; correct position; A', suture needle undamaged. B, Suture needle held incorrectly at tip; B', tip of suture needle damaged. C, Suture needle held incorrectly behind curvature; C', needle bent as a result.

1. *Penetration:* The needle point is positioned perpendicular (90°) to the tissue surface and underlying bone. It is then inserted completely through the tissue until the bone is engaged. This is as opposed to the usual 30° needle insertion angle (see Figure 3-6A).
2. *Rotation:* The body of the needle is now rotated about the needle point in the direction opposite to that in which the needle is intended to travel. The needle point is held

tightly against the bone so as not to damage or dull the needle point (see Figure 3-6B).

3. *Glide:* The needle point is now permitted to glide against the bone for only a short distance. Care must be taken not to lift or damage the periosteum (see Figure 3-6C).
4. *Rotation:* As the needle glides against the bone, it is rotated about the body, following its circumferenced outline. In this way, the needle will not be pushed through the tissue,

resulting in lifting or tearing of the periosteum (see Figure 3-6, D and E).

5. *Exit:* The final stage of gliding and rotation is needle exit. The needle is made to exit the tissue through the gentle application of pressure from above, thus allowing the tip to pierce the tissue. If digital pressure is to be used, care must be used to avoid personal injury (see Figure 3-6F).

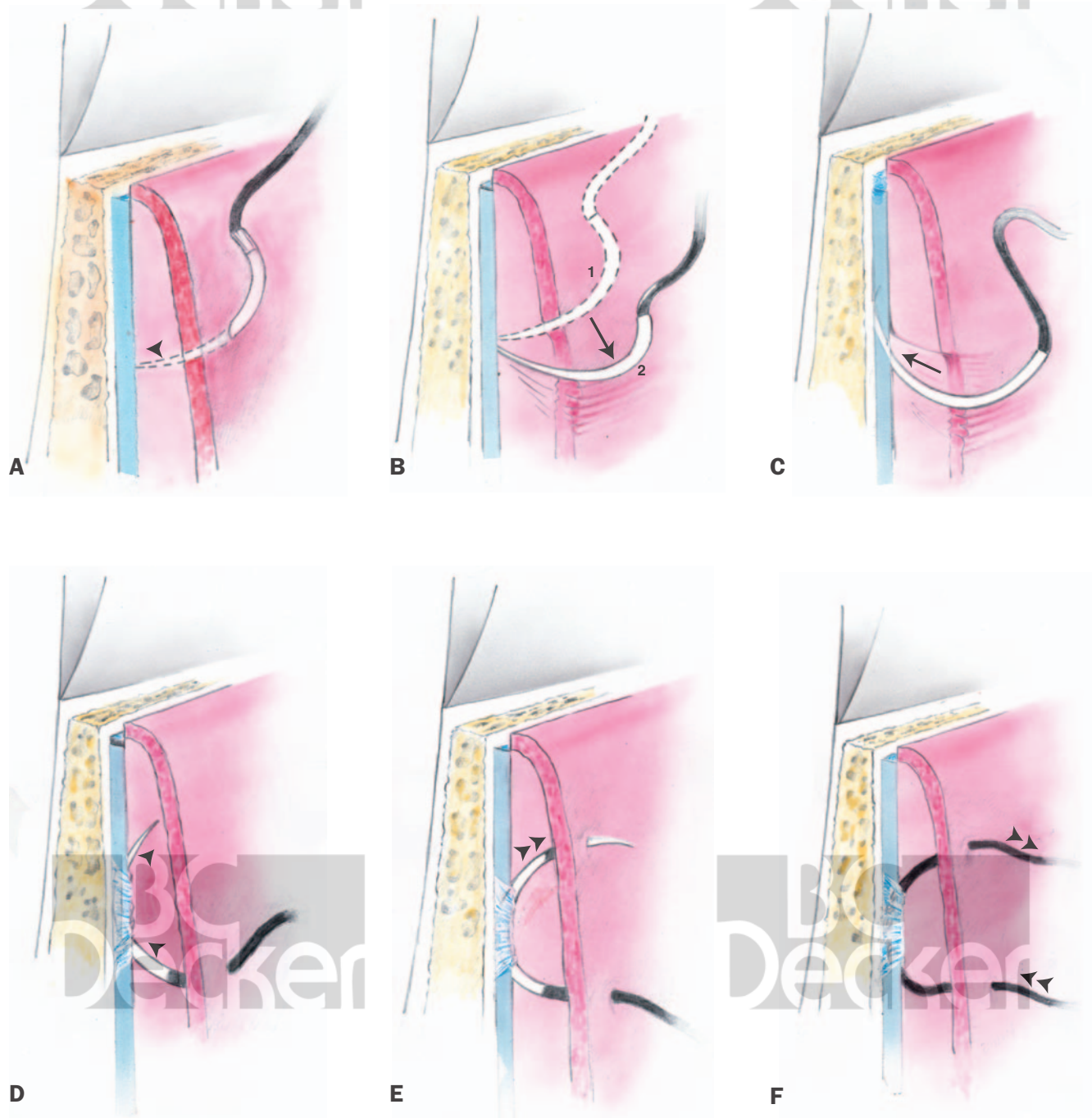


FIGURE 3-6. Periosteal suturing. A, Needle penetration; needle point is perpendicular to bone. B, Rotation of needle body about point. C,D, The needle is moved along the bone below the periosteum. E, Rotation about needle body permitting point to exit periosteum and tissue. F, Completed periosteal suture.

Interrupted Sutures

Indications

Interrupted sutures are most often used for the following:

1. Vertical incision
2. Tuberosity and retromolar areas
3. Bone regeneration procedures with or without guided tissue regeneration
4. Widman flaps, open flap curettage, unrepositioned flaps, or apically positioned flaps where maximum interproximal coverage is required
5. Edentulous areas
6. Partial- or split-thickness flaps
7. Osseointegrated implants

Types

In Figure 3-7, we see the four most commonly used interrupted sutures:

1. Circumferential, direct, or loop (see Figure 3-7A)
2. Figure eight (see Figure 3-7B)
3. Vertical or horizontal mattress (see Figure 3-7C)
4. Intrapapillary placement (see Figure 3-7D)

Technique

Figure Eight and Circumferential Sutures. Suturing is begun on the buccal surface 3 to 4 mm from the tip of the papilla to prevent tearing of the thinned papilla. The needle is first inserted into the outer surface of the buccal flap and then either through the outer epithelialized surface (figure eight) (Figure 3-8) or the connective tissue under the surface (circumferential) (see Figure 3-8A) of the lingual flap. The needle is then returned through the embrasure and tied buccally.

When interproximal closure is critical, the circumferential suture will permit greater coaptation and tucking down of the papilla because of the lack of intervening suture material between the tips of the papilla.

Mattress Sutures. Mattress sutures are used for greater flap security and control; they permit more precise flap placement, especially when combined with periosteal stabilization. They also allow for good papillary stabilization and placement. *The vertical mattress (nonperiosteal) suture is recommended for use with bone regeneration procedures because it permits maximum tissue clo-*

sure while avoiding suture contact with the implant material, thus preventing wicking. They are left for 14 to 21 days (Mejias, 1983) and therefore require a suitable material (eg, nylon, e-PTFE) that is biologically inert and does not rapidly “wick.”

Vertical Mattress Technique. The flap is stabilized and a P-3 needle is inserted 7 to 10 mm apical to the tip of the papilla. It is passed through the periosteum (if periosteal sutures are being used), emerging again from the epithelialized surface of the flap 2 to 3 mm from the tip of the papilla. The needle is brought through the embrasure, where the technique is again repeated lingually or palatally. The suture is then tied buccally (Figure 3-9A).

Horizontal Mattress Technique. A P-3 needle is inserted 7 to 8 mm apical to and to one side of the midline of the papilla, emerging again 4 to 5 mm through the epithelialized surface on the opposing side of the midline (Figure 3-9B). The suture may or may not be brought through the periosteum. The needle is then passed through the embrasure, and the suture, after being repeated lingually or palatally, is tied buccally. For greater papillary stability and control, the double parallel

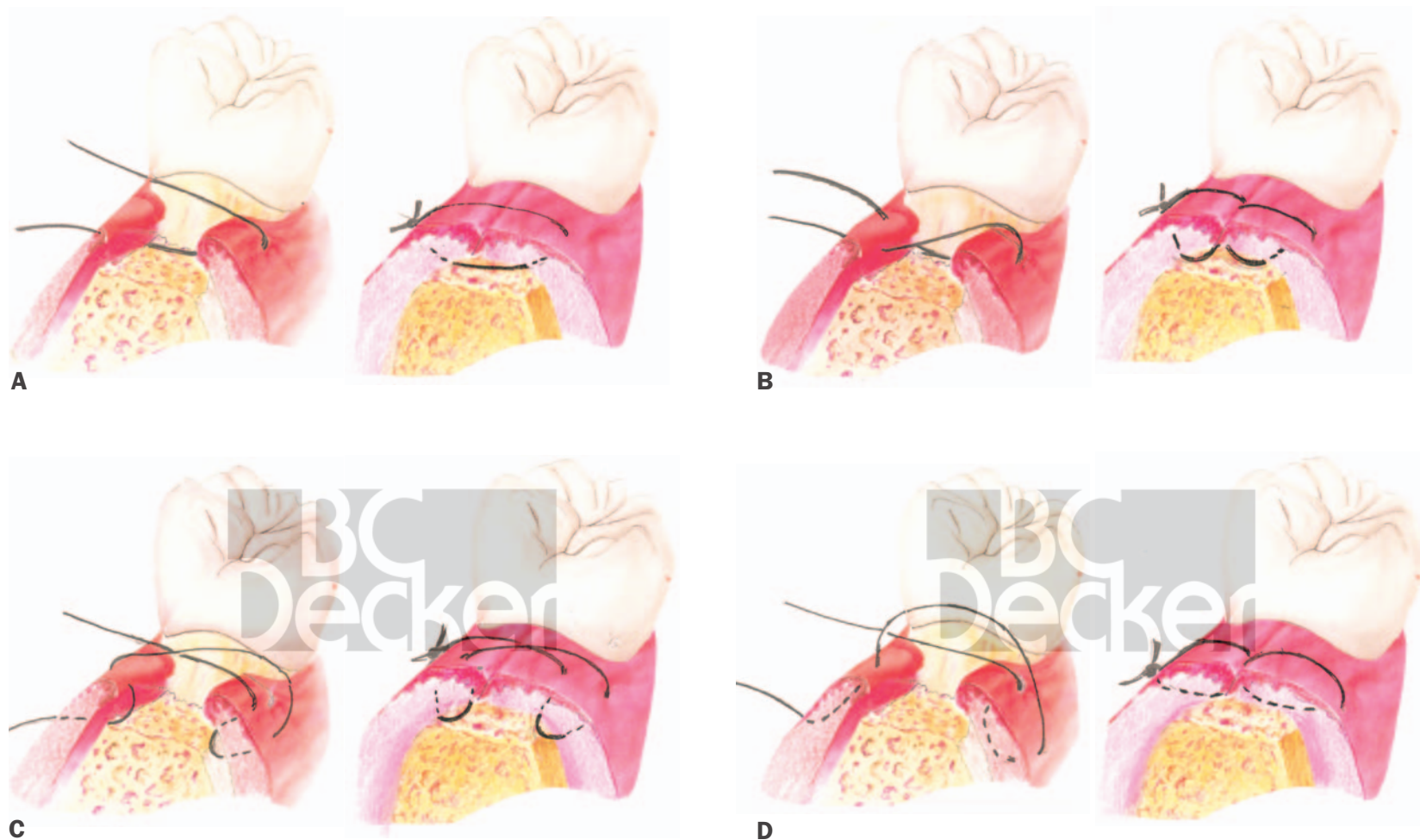


FIGURE 3-7. Four interrupted sutures. A, Circumferential. B, Figure-eight. C, Vertical mattress. D, Intrapapillary.



FIGURE 3-8. A, Circumferential suture. B, Figure-eight suture.

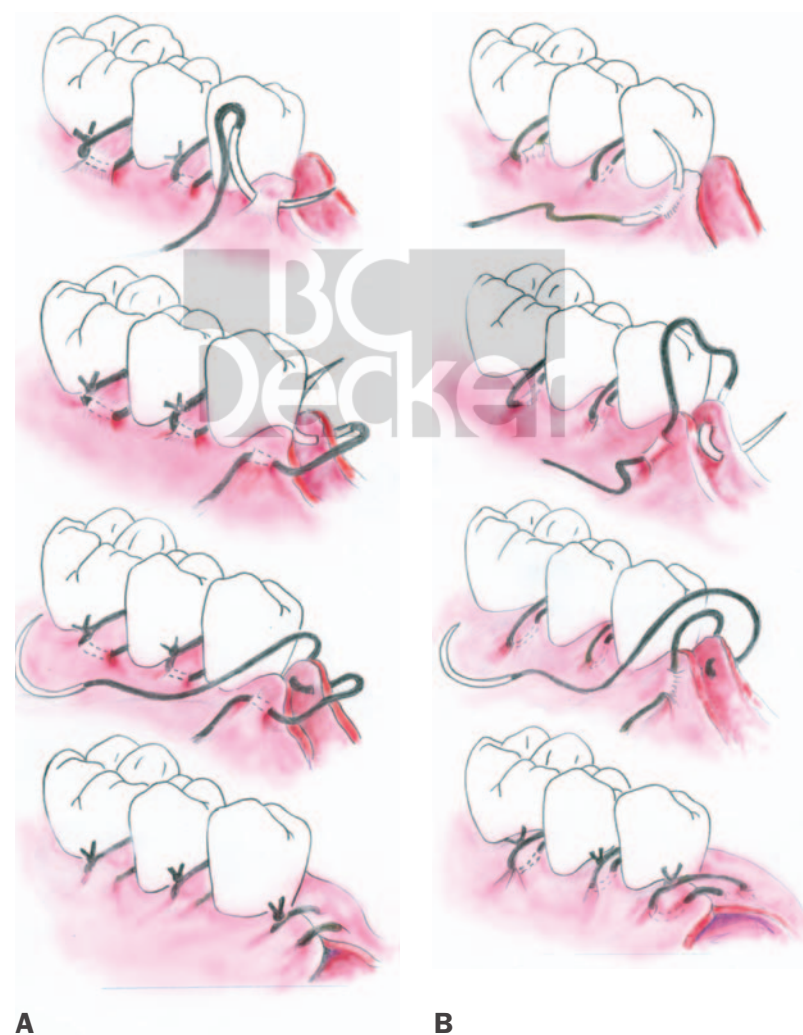


FIGURE 3-9. A, Horizontal mattress suture. B, Vertical mattress suture.

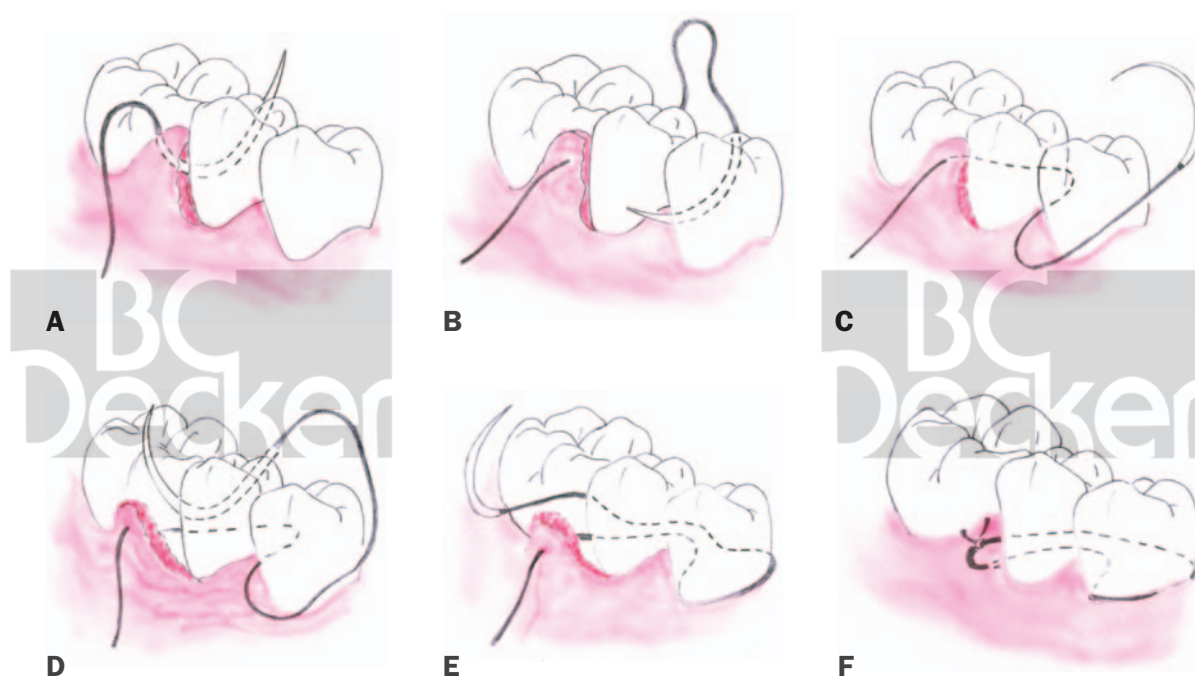


FIGURE 3-10. Sling suture about adjacent tooth.

strands of this suture can be made to cross over the three tops of the papillae. This is the double crossed-over suture.

Intrapapillary Placement. *This technique is recommended for use only with modified Widman flaps and regeneration procedures in which there is adequate thickness of the papillary tissue.*

A P-3 needle is inserted buccally 4 to 5 mm from the tip of the papilla and passed through the tissue, emerging from the very tip of the papilla. This is repeated lingually and tied buccally, thus permitting exact tip-to-tip placement of the flaps (see Figure 3-7D).

Sling Suture. The sling suture is primarily used for a flap that has been raised on only one side of a tooth, involving only one or two adjacent papillae. It is most often used in coronally and laterally positioned flaps. The technique involves use of one of the interrupted sutures, which is either anchored about the adjacent tooth (Figure 3-10) or slung around the tooth to hold both papillae (Figure 3-11).

Specialized Interrupted Suturing Techniques for Bone Regeneration and Retromolar and Tuberosity Areas. *Laurell Modification.* Laurell modified mattress suture (1993) (Figure 3-12) for coronal flap positioning and primary flap coverage is a technique which, although capable of being employed for all regenerative techniques, is used

predominantly when standard interproximal incisions are used. Start buccally below the papilla (2–4 mm) and insert the needle to and then through the undersurface of the lingual flap (Figure 3-12A1). The suture needle is then reinserted lingually 2–4 mm above the initial suture and continued to and then through the buccal flap (Figure 3-12A2). The suture is then brought lingually over the coronal aspect of the flap and through the loop (Figure 3-12A3). The suture is afterwards returned buccally and sutured (Figure 3-12A4). Figure 3-12B shows the completed suture.

Modified Flap Suturing Technique. This technique (Cortellini et al 1995) was introduced specifically for achieving maximum interproximal coverage and primary closure over intrabony defect is treated by GTR. The modified flap technique (Figure 3-13) requires the initial incision be made at the buccal line angles in the area of the interproximal defect. It is a papillary preservation technique. The suturing permits coronal positioning, flap stabilization, and primary interproximal closure. The first suture is begun buccally 5–6 mm below the initial incision (Figure 3-13A1). The suture is passed through the buccal and palatal flaps. It is then reinserted palatally and allowed to exit the buccal flap 2 mm above the initial placements. This is tied off and should stabilize the body of the flap. The second suture is now begun 3–4 mm below the initial inci-

sion and above the first suture (Figure 3-13A2). The suture is passed through the interproximal papilla and returned as a horizontal mattress suture on the buccal surface and tied off.

Retromolar Suture Modification for Primary Coverage. This technique (Hutchenson 2005) (Figure 3-14) is specially designed for gaining intimate tissue-tooth contact where regeneration is being attempted. It is employed when there is an intrabony defect distal to the last tooth on the lower teeth. It not only permits primary flap closure but close approximation of the tissue on the distal aspect of the tooth. Figure 3-14A shows a defect distal to the last tooth. The arrows on Figure 3-14B indicate desired movement of flap and dotted lines indicate ideal flap position. Flap ideally should be positioned against distal surface of tooth with primary closure. Suture is begun on the mesiobuccal of the terminal tooth (Figure 3-14C1). The suture is passed through interproximal to the distal and inserted through only the undersurface of the buccal flap. The suture is brought almost 360° around the tooth starting lingually and continuing buccally until again reaching the distal surface (Figure 3-14C2). The needle is passed through the undersurface of the lingual flap and tied on the buccal surface (Figure 3-14C3). Figure 3-14D shows suturing having been completed and primary coverage attained.

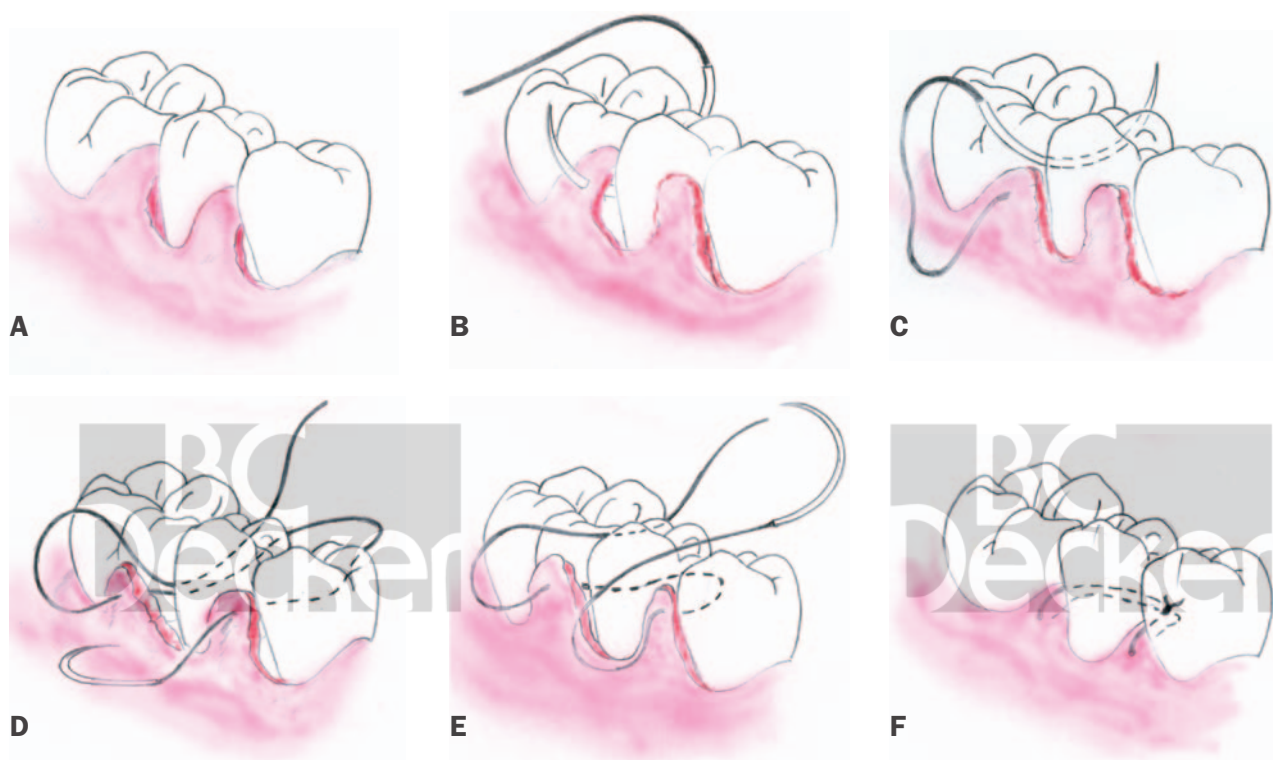


FIGURE 3-11. Sling suture about single tooth.

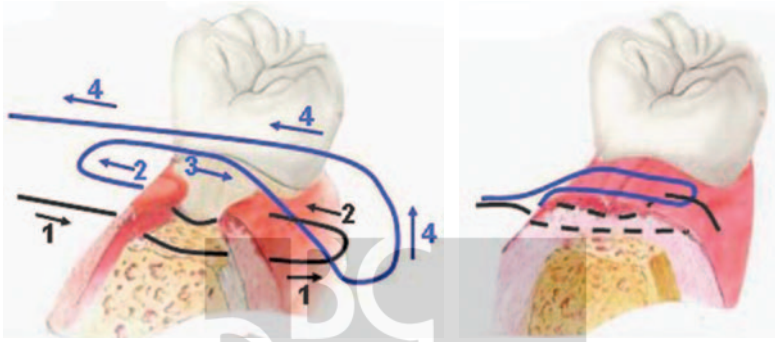


FIGURE 3-12. Laurell modified mattress suture (see text).

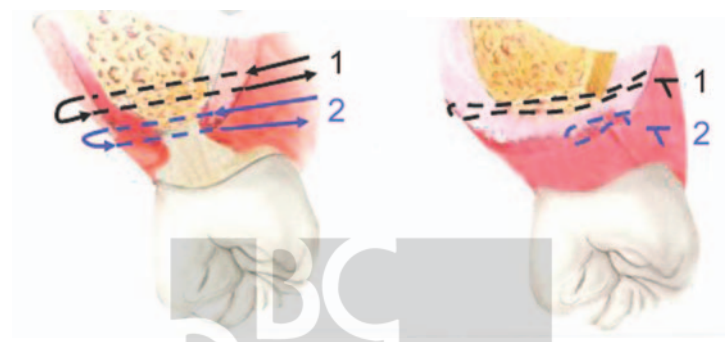


FIGURE 3-13. Modified flap suturing technique (see text).

Continuous Sutures Sling

When multiple teeth are involved, the continuous suture is preferred.

Advantages

1. Can include as many teeth as required
2. Minimizes the need for multiple knots
3. Simplicity
4. The teeth are used to anchor the flap
5. Permits precise flap placement
6. Avoids the need for periosteal sutures
7. Allows independent placement and tension of buccal and lingual or palatal flaps. Buccal flaps can be positioned loosely, whereas lingual and palatal flaps are pulled more tightly about the teeth.
8. Greater distribution of forces on the flaps

Disadvantages

The main disadvantage of continuous sutures is that if the suture breaks, the flap may become

loose or the suture may come untied from multiple teeth.

Types

The choice of continuous suture depends on the operator's preference. These, too, can be periosteal or nonperiosteal:

1. Independent sling suture
2. Mattress sutures
 - a. Vertical
 - b. Horizontal
3. Continuous locking

Technique

Independent Sling Suture

The continuous sling suture (Figure 3-15), although most often begun as a continuation of tuberosity or retromolar suturing (see Figure 3-15A), can also be started with a looped suture about the terminal papilla (buccal, lingual, or palatal). It is then continued through the next

interproximal embrasure (see Figure 3-15B) in such a manner that the suture is made to encircle the neck of the tooth (see Figure 3-15C). The needle is then passed either over the papilla and through the outer epithelialized surface or underneath and through the connective tissue undersurface of the papilla. The needle is passed again through the embrasure and continued anteriorly (Figure 3-15D). This procedure is repeated through each successive embrasure until all papillae have been engaged.

Note: For maximum flap control, it is best to pass the needle through the connective tissue undersurface of the papilla.

A terminal end loop (Figure 3-15E) is then used if a single flap has been reflected or if the flaps are to be sutured independently. In this manner, the flaps are tied against the teeth as opposed to each other.

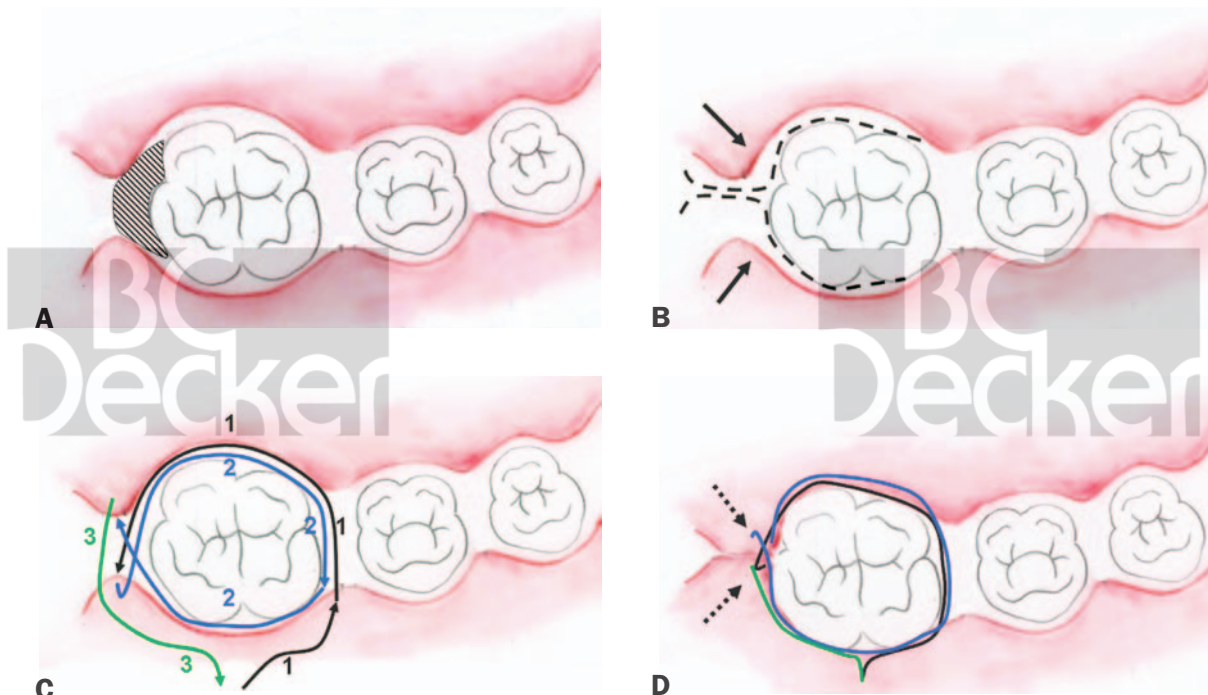


FIGURE 3-14. Retromolar area modified suture technique (see text).

Terminal End Loop. On completion of suturing, the suture is tied off against the tooth as opposed to the other flap. This is accomplished by leaving a loose loop of approximately 1 cm length of suture material before the last embrasure. When the last papilla is sutured and the needle is returned through the embrasure, the terminal end loop is used to tie the final knot (Figure 3-15F–I).

Modification. When two flaps have been reflected and after the first flap has been sutured (Figure 3-16A), it is often desirable to continue about the distal surface of the last tooth (Figure 3-16B), repeating the procedure on the opposing flap (Figure 3-16C) and then tying off in a terminal end loop (Figure 3-16D and E).

Alternative Procedure. This technique simultaneously slings together both the buccal and lingual or palatal flaps.

INDICATIONS.

1. When flap position is not critical
2. When buccal periosteal sutures are used for buccal flap position and stabilization
3. When maximum closure is desired (unreposition or Widman flaps or bone regeneration)

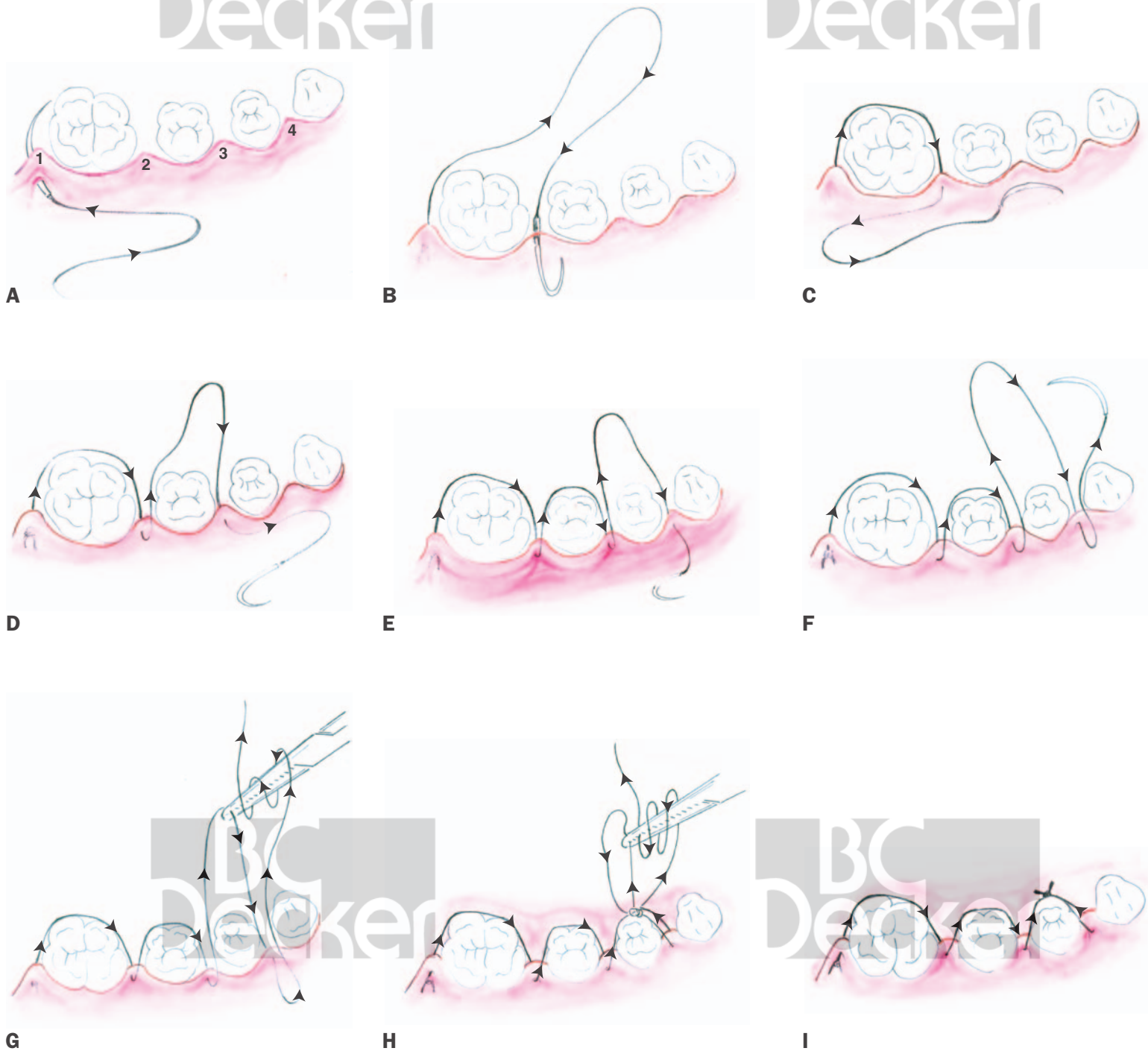


FIGURE 3-15. Continuous sling suture with terminal end loop.

Technique

After the initial buccal and lingual tie, the suture is passed buccally about the neck of the tooth interdentally and through the lingual flap. It is then again brought interdentally through the buccal papilla and back interdentally about the lingual surface of the tooth to the buccal papilla. Then it is brought about the lingual papilla and then the buccal surface of the tooth. This alternating buccal-lingual suturing is continued until the suture is tied off with a terminal end loop (Figure 3-17).

Vertical and Horizontal Mattress Suture. When greater papillary control and stability and more precise placement are required or to prevent flap movement, vertical or horizontal mattress sutures are used. This is most often the case on the palate, where additional tension is often required, or when the papillary tissue is thin and friable.

Technique. The procedure is identical to that previously described for the independent papillary sling suture (see Figure 3-15), except that vertical or horizontal mattress sutures are substituted for the simple papillary sling. The technique is similar to that previously described for the interrupted mattress sutures.

Locking. The continuous locking suture is indicated primarily for long edentulous areas, tuberosities, or retromolar areas. It has the advantage of avoiding the multiple knots of interrupted sutures. If the suture is broken, however, it may completely untie.

Technique. The procedure is simple and repetitive. A single interrupted suture is used to make the initial tie. The needle is next inserted through the outer surface of the buccal flap and the underlying surface of the lingual flap. The needle is then passed

through the remaining loop of the suture, and the suture is pulled tightly, thus locking it. This procedure is continued until the final suture is tied off at the terminal end (Figure 3-18).

Suture Removal

Sutures are used for wound stabilization and should be removed when sufficient tissue strength has been achieved. This is usually between 5 and 10 days, and in most instances, these sutures are removed in 7 days.

Materials

1. Scissors
2. Cotton pliers
3. Double-ended scaler
4. Hydrogen peroxide
5. Topical anesthetic
6. Cotton swabs

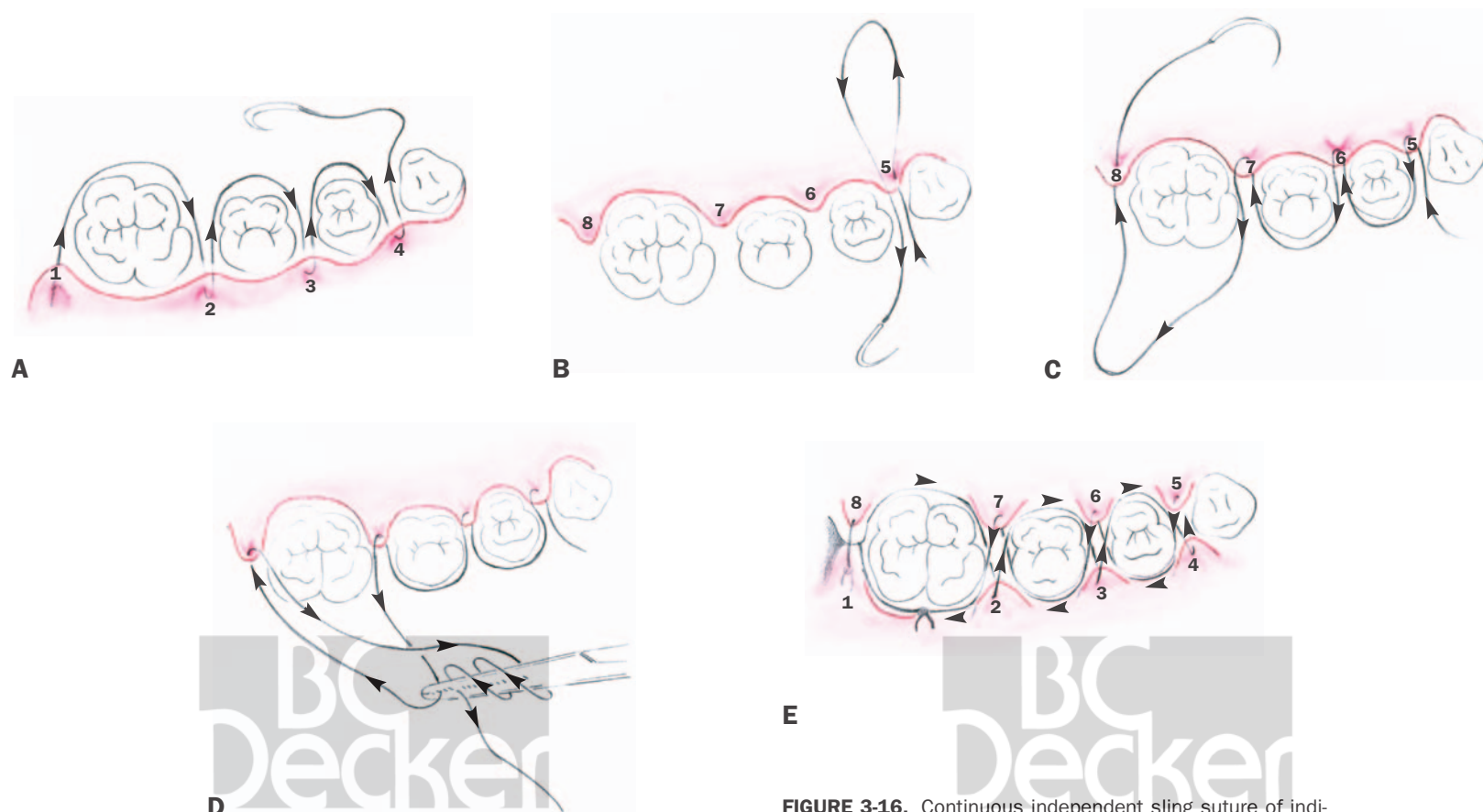


FIGURE 3-16. Continuous independent sling suture of individual flaps.

Method

1. The scaler is used to remove the dressing. The dressing should be loosened first in an apicocoronal direction. This will place the tension against the teeth and not the tissue.

2. The area is then gently swabbed with hydrogen peroxide to move clotted blood, serum, and debris and is rinsed with warm water.

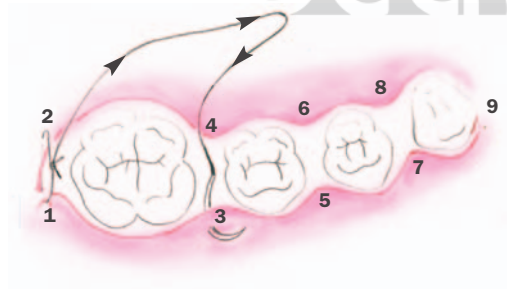
3. Topical anesthetic may be optionally applied
4. A sharp scissors should be used to cut the loops of the individual or continuous sutures. **Note: It is often helpful to use the tip of an explorer to gently lift the suture off the tissue prior to cutting.** This will avoid tissue damage and unnecessary pain.

5. Interrupted sutures need be cut only on the facial aspect close to the tissue.
6. Continuous sutures will require cutting both buccally and lingually.

7. Once the sutures are removed, the area should again be swabbed with hydrogen peroxide or chlorhexidine gluconate to remove any residual debris.

8. The teeth should be polished for complete removal of debris and stain.

9. Plaque control should again be reviewed.



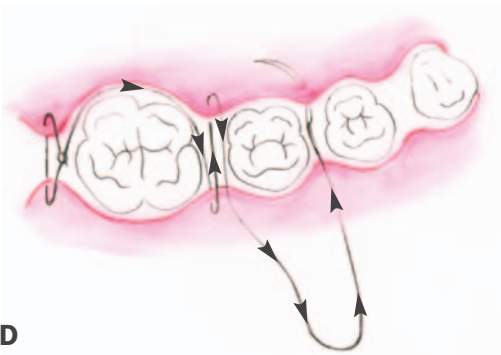
A



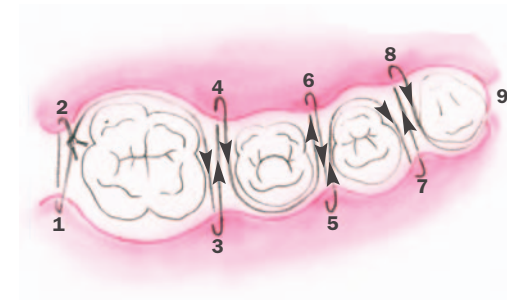
B



C



D



E

FIGURE 3-17. Modification of continuous sling suture. This technique permits simultaneous suturing of both flaps.

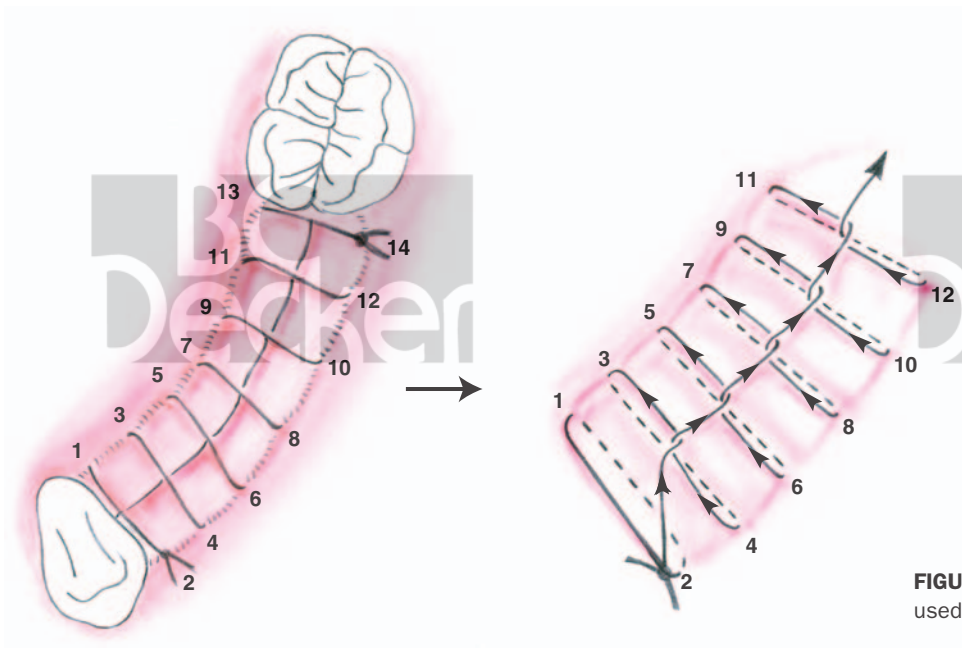


FIGURE 3-18. Continuous locking suture used primarily for edentulous areas.

Scaling and Root Planing

Scaling is the removal of plaque, calculus, and stain from the crown and root surfaces. This is as opposed to root planing, which is the definitive removal of cementum or dentin from the root surface in an attempt to smooth rough surfaces and dislodge calculus. Without clean, smooth, hard roots, the results of curettage may be limited because rough roots are foci for plaque accumulation and attachment of calculus.

Scaling and root planing are the first steps in the overall treatment of adult periodontitis. They are geared toward removing gingival inflammation, eliminating or shifting the bacterial microorganisms from gram-negative anaerobes to gram-positive foculative bacteria to establish health (Slots and colleagues, 1979; Rosenberg and Evian, 1982). In areas of minimal pocketing where inflammation can be controlled and disease progression stopped, no further treatment is indicated. Walker and Ash (1976), Waerhaug (1978), Caffesse and colleagues (1986), and Buchanan and Robertson (1987) have all shown that in pockets greater than 3 mm, the ability to remove all calculus is significantly reduced and there is a low predictability for detection of residual calculus by instrumentation or x-ray studies. The inability to remove calculus in furcations and concavities is even greater (Maitia and colleagues, 1986). Although less effective in these deeper pockets, scaling and root planing are still an important contributor to the reduction in inflammation and control of subgingival bacteria (Sato and colleagues, 1993).

Note: Quirynen and colleagues (1999, 2000) and Mongardini and colleagues (1999) have shown that completing full-mouth scaling and root planing in one or two visits reduces the chance of bacterial repopulation from untreated areas.

Curettage

Curettage is a closed, definitive surgical procedure performed under local anesthesia and aimed at pocket reduction, elimination, reattachment, or new attachment. It is indicated primarily for edematous suprabony pockets, where shrinkage and a reduction in inflammation will result in a shallow sulcus, or prior to surgery for pocket elimination to reduce inflammation (Hirschfeld, 1952). It is performed with sharp curets in an attempt to remove (1) the sulcular

epithelium and the epithelial attachment and (2) the inflamed connective tissue of the pocket wall (Figure 4-1).

It is important to note that although scaling, root planing, and curettage are difficult, time-consuming, and often tedious procedures, they are basic to periodontal therapy and should be mastered by all clinicians.

The consensus report of the proceedings of the World Workshop in Clinical Periodontics (1989) came to the following conclusions:

Gingival curettage as a separate procedure has no justifiable application during active therapy for chronic adult periodontitis. Gingival curettage is not indicated if new attachment is the goal of therapy. This conclusion was arrived at due to the difficulty of assessing what if any the beneficial effects of curettage were since they are almost always combined with root instrumentation.

The report further pointed out that studies have not been able to find any significant differences between scaling and root planing with and without curettage.

Indications

1. Edematous and inflamed tissues
2. Shallow pockets
3. Suprabony pockets
4. As part of initial preparation prior to open surgical procedures in an attempt to achieve tissue quality that can be handled easily
5. Progressive attachment or alveolar bone loss
6. Increased levels of pathogenic microorganisms

Contraindications

1. Fibrotic tissue
2. Deep pockets
3. Furcation involvements

Treatment of Underlying Osseous Defects

Procedure

1. Scaling, root planing, and curettage require local anesthesia to control pain and hemorrhage. Figure 4-2A outlines the three critical areas of treatment: the root surface, the sulcular epithelium, and the underlying connective tissue.
2. Step 1 is subgingival scaling for removal of calculus, plaque, and soft cementum. The

scaler is placed in the pocket with the bevel at an angle between 45 and 90° to the tooth and drawn in a vertical, oblique, or horizontal motion (see Figure 4-2B).

3. Sharp curets are then placed into the pocket with the cutting edge toward the tissue. Digital pressure to support the gingival tissue enhances the cutting efficiency of the curet. The curet is moved generally in a circular or horizontal motion about the tooth. The sulcular epithelium and epithelial attachment are removed first (Figure 4-2C).
4. Once the epithelial lining is removed (Figure 4-2D), the inflamed connective tissue of the inner pocket wall and that above the alveolar crest is removed (Figure 4-2E).
5. On completion of the procedure, the area is flushed and all tissue tags are removed. Digital pressure is now applied to ensure proper tissue adaptation and clot formation. Suturing is indicated if the clot area has been disrupted and the papillae have been separated. A periodontal dressing may be necessary.
6. Healing will result in shrunken, firm, well-adapted, and well-contoured tissue (Figure 4-2F).



FIGURE 4-1. Removal of the sulcular tissue wall. A, Scaler inserted. B, Removal of the inflamed pocket wall.

The procedure is clinically depicted in Figure 4-3, and the results that may be attained are shown in Figure 4-4.

Flap Débridement Surgery

These procedures permit the surgical débridement of root surfaces and removal of soft tissue following the reflection of a mucoperiosteal flap. They

have been described as open flap curettage, the modified excisional new attachment procedure (ENAP), and, most notably, the modified Widman flap. They are repositioned (unrepositioned) flaps whose primary purpose is to gain access to the roots for definitive scaling and root planing in areas in which the pockets are 4 mm or more in depth. Their purpose is for control of chronic adult periodontitis and not for gaining new attachment.

ENAP and Modified ENAP

The ENAP, as outlined by Yukna and colleagues (1976), was an attempt to overcome some of the limitations of closed gingival curettage and gain new attachment in areas of suprabony pockets. The ENAP, unlike scaling and curettage, was developed to ensure complete removal of sulcular epithelium, epithelial attachment, granulated and

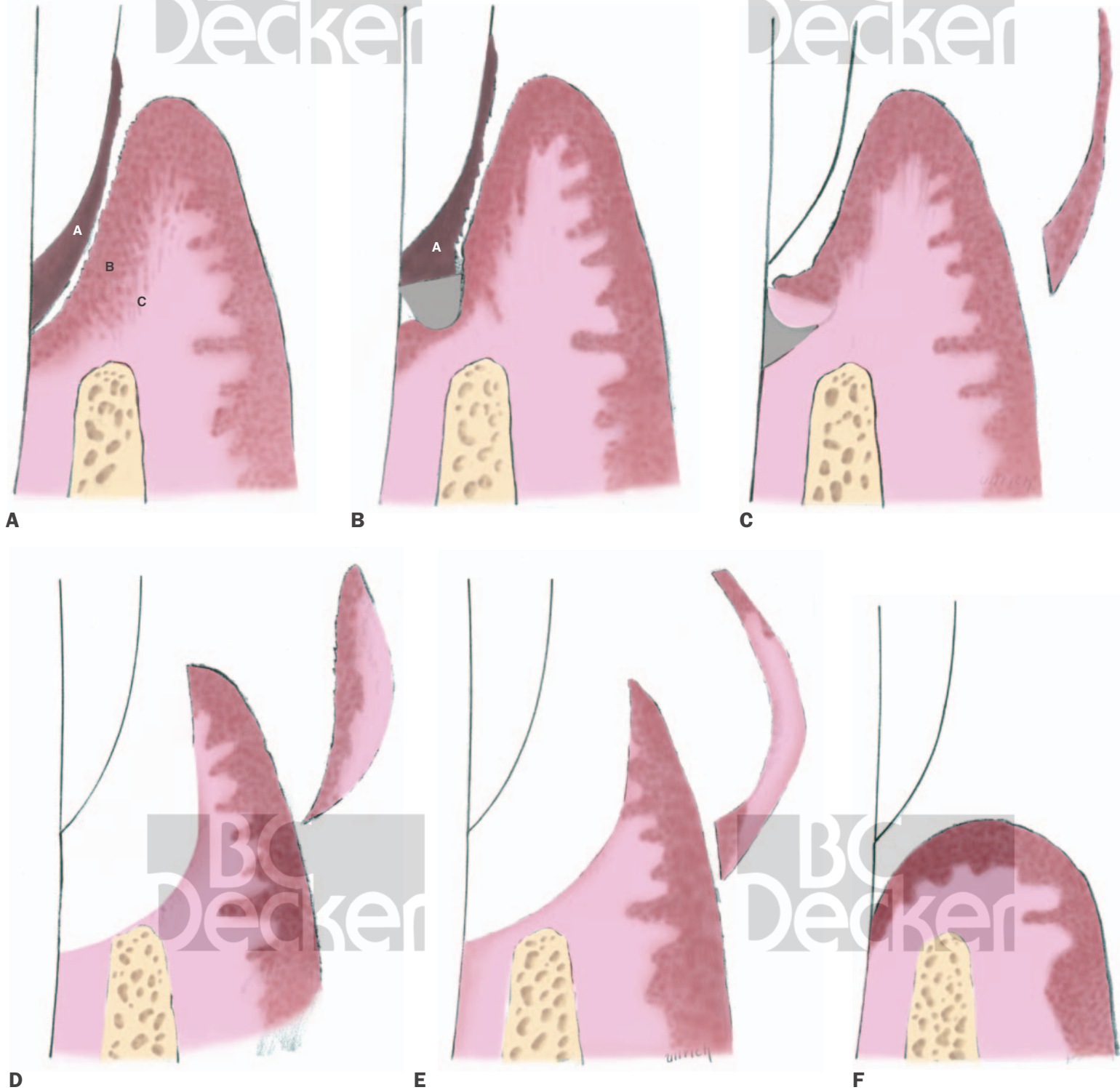


FIGURE 4-2. Scaling and curettage technique. *A*, The three zones that must be removed: *A*, subgingival plaque and calculus; *B*, sulcular epithelium and epithelial attachment; and *C*, inflamed connective tissue wall of the pocket. *B*, Scaler in position to remove zone *A*. *C*, Zone *A* removed and curet in position to remove zone *B*. *D*, Zone *B* removed and curet positioned to remove zone *C*. *E*, Zone *C* removed, and only healthy tissue remains. *F*, Healed tissue. Shrinkage has resulted in pocket elimination.



FIGURE 4-3. Scaling and curettage procedure. *A*, Inflamed, enlarged edematous tissue. *B*, Probe showing pocketing of 3 to 5 mm. *C*, Curettage begun with the open face of the scaler toward the tissue. *D*, Scaling and root planing are begun with the scaler inserted at a 45° angle to the tooth. *E*, Scaler moved in an upward pulling motion. *F*, Two months after treatment. Note shrinkage of tissue and excellent contour.

inflamed connective, subgingival calculus, and softened cementum. Basically, it is curettage with a surgical blade, which increases access and visibility with minimal tissue reflection.

When performing the ENAP, the dentist uses a scalpel or sharp knife for a definitive sulcular incision, which allows greater access to and visibility of the roots for the removal of calculus and

softened cementum. No vertical incisions are made, and the procedure is confined to the keratinized tissue. The sharp, clean incision of ENAP heals faster than the ragged incision of curettage.



FIGURE 4-4. Results obtainable with scaling and curettage. *A*, *B*, and *C*, Before. *A'*, *B'*, and *C'*, After.

This procedure is easy to perform and within the capabilities of the general dentist.

Indications

1. Suprabony pockets
2. Adequate keratinized tissue
3. When esthetics are unimportant

Advantages

1. Improved root visualization
2. Complete removal of sulcular epithelium and epithelial attachment
3. Minimal gingival trauma
4. No loss of keratinized gingiva

Disadvantages

1. Difficult to determine apical extent of epithelial attachment
2. Does not result in new attachment

Contraindications

1. Pockets exceed mucogingival junction
2. Edematous tissue
3. Lack of keratinized tissue
4. Osseous defects must be treated
5. Hyperplastic tissue
6. Close root proximity
7. Furcation involvement
8. Probing depths of 3 mm or less

Procedure

1. Scaling and root planing are performed at least 1 week before the ENAP, which increases the healing potential.
2. Adequate anesthesia is given, after which pockets are checked to ensure that the zone of keratinized tissue is adequate and that the pockets do not exceed the mucogingival junction (Figure 4-5, A and B).
3. With a no. 11 or no. 15 scalpel blade, a scalloped, partial-thickness, inverse-beveled incision is made (Figure 4-5C) from the crest of the gingiva to the base of the sulcus (Figure 4-5D).
4. The incisions are carried facially, lingually, and interproximally as far as possible (Figure 4-5E). The papilla is thinned interproximally (Figure 4-5F) to remove any inflamed connective tissue and the triangular wedge of interproximal tissue. This tissue is difficult to remove once the flap is free.
5. With scalers and curets, the inflamed granulated and excised tissues are removed. All tissue tags are carefully removed. The root is scaled hard and smooth and is free of calculus and softened cementum (Figure 4-5, G and H), and the area is flushed with normal saline to remove debris, blood clots, and tissue tags.

6. Interproximal sutures are used to position the tissue as closely as possible to the presurgical height and to adapt the papillae and tissue tightly about the necks of the teeth. Primary closure is desirable (Figure 4-5, I and J).
7. A periodontal dressing is now placed interproximally, without being forced.

The procedure is shown clinically in Figure 4-6.

Modified ENAP Modification

In 1977, Fredi and Rosenfeld modified the technique by advocating a partial-thickness inverse-beveled incision down to the crest of bone (Figure 4-7A) to completely remove tissue about the periodontal ligament (Figure 4-7B). The flaps were then sutured at the presurgical height (Figure 4-7C). The technique is basically the same in all other aspects.

Modified Widman Flap

A report describing the modified Widman flap procedure was published by Ramfjord and Nissle in 1974. This procedure not only became a principal procedure of Ramfjord's long-term study on surgical techniques, it has also had a profound impact on how many clinicians treat periodontal disease. It was an extension or a progression of the Widman flap (apically displaced flap) procedure, which the authors found to have a rather "unpredictable ratio between success and failures..."

The technique as outlined is technically demanding and extremely exacting. It is described as a modification of subgingival curettage. The flaps are raised by the use of small vertical incisions to gain access to the roots. This allows easier removal of calculus and less mechanical trauma in removal of the pocket lining than that afforded by closed gingival curettage. The aim is to achieve maximum healing with minimum loss of periodontal tissue.

Advantages

1. Minimal bone removal
2. Immediate close postsurgical contact of healthy collagenous tissue with the tooth surface
3. Maximum conservation of periodontal tissue
4. Esthetic desirability
5. Facilitation of oral hygiene
6. Less root exposure with less sensitivity
7. Less mechanical trauma than closed curettage

Disadvantages

1. Technically demanding and exacting
2. Requires a high degree of technical skill
3. Interproximal flaps require exact placement
4. Immediate unfavorable interproximal contours when dressings are first removed

The original article shows no clinical examples of the procedures, and the drawings are extremely basic. This apparent lack of detail has resulted in some confusion by clinicians as to the exact technique.

Procedure

1. Sterile technique is recommended.
2. Adequate anesthesia is used to control pain and hemorrhage.
3. Figure 4-8A represents the basic outline of the incisions, showing an exaggerated scalloped palatal incision with maximum preservation of interproximal tissue. Buccally, if pockets are greater than 2 mm, the inverse bevel is made 0.5 to 1 mm away from the free gingival margin.
4. The initial or primary incision is an inverse-beveled, partial-thickness, thinning incision made with a no. 11 or no. 15 scalpel blade held parallel to the long axis of the tooth and directed toward the crest of bone. Palatally, the incision is more angulated, permitting thinning of the tissue (Figure 4-8B). This is especially important interproximally, where the papillae must be thinned adequately to remove all remnants of epithelium to promote reattachment of connective tissue. **Note: The removal of all epithelial remnants has been shown to be impossible (Bahat and colleagues, 1984; Fisher and colleagues, 1982).**
5. Small vertical incisions are now made 2 to 3 mm apically and the flap is raised, separating the periosteum (Figure 4-8, B and C) and exposing only a small amount of alveolar bone.
6. A secondary sulcular incision is made about the neck of the teeth from the base of the sulcus to the alveolar crest (Figure 4-8, D and E). This frees the inner or secondary flap.
7. The buccal and lingual flaps are now either pushed aside or held back to allow interproximal incisions to be made to remove the loosened collar of tissue at the alveolar crest (Figure 4-8F). These incisions follow the contour of the alveolar crest.
8. Scalers and curets are used to remove the collar of tissue and scale and plane the exposed roots (Figure 4-8G). Care should be taken to keep the healthy gingival fibers at the crest intact if possible. Irrigation is done only with sterile saline solutions.
9. When intraosseous defects are present, all fibers are removed to promote possible regeneration (Figure 4-8H).
10. For proper flap adaptation, it may be necessary to remove some bone on the outer alveolar surfaces (osteoplasty) or to thin the flap further (Figure 4-8I). **Note: No mention is made in the original article of how much bone is to be removed in attempting flap adapta-**



FIGURE 4-5. Excisional new attachment procedure. A and B, Preoperative views showing suprabony pockets and an adequate zone of keratinized gingiva. C, A scalloped labial incision is made at the crest of the gingiva. D, The incision is carried down to the base of the pocket. E and F, Facial and cross-sectional views showing that the interproximal papillae are partially dissected to remove the thick triangular wedge of tissue. In effect, the papillae are treated as a partial-thickness flap. G, The papillae are reflected slightly for access and the root is scaled and root planed. H, Cross-sectional view showing the inflamed inner wall removed and the root scaled. I, Flap sutured at presurgical height. J, Healed tissue with pockets eliminated as a result of shrinkage and tight adaptation to the tooth.

tion. Proper flap adaptation with primary interproximal closure is critical; without it, one will end up with “poor results with residual inflamed and deep periodontal pockets.”

11. Interrupted sutures are used to adapt tissue tightly to teeth (Figure 4-8J). Figure 4-8K

shows that when suturing, a deep bite of tissue is not taken so as to prevent interproximal buckling of margins. **Note: This is sometimes difficult, if not impossible, with thin tissue.** The procedure is outlined clinically in Figures 4-9 through 4-10.



FIGURE 4-6. Excisional new attachment procedure. A, Before. B, Scalloped sulcular incision outlined. Lined portion shows that only a miniflap is raised. C, Sulcular incision made to the base of the pocket with a no. 11 blade. D, Continuation of incision interdentally. E, Flap reflected, exposing granulation tissue. F, Scaling completed between teeth 1 to 8, removing tissue between teeth 6 and 7. G, Interrupted suture placed.

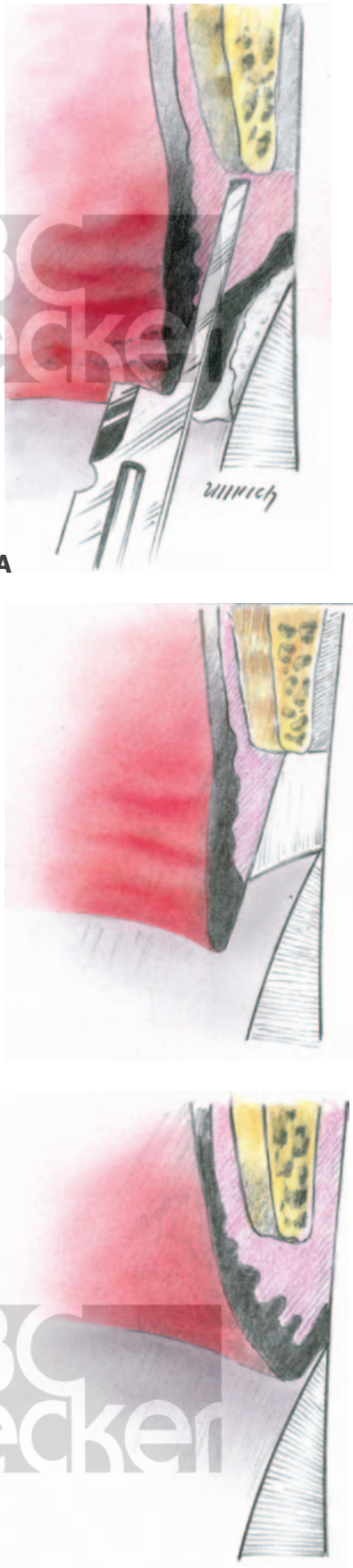


FIGURE 4-7. Modification of the excisional new attachment procedure. A, Initial incision made to the crest of bone instead of the base of the pocket. B, Inner wall removed down to the crest of bone and periodontal ligament space. C, Healed tissue.

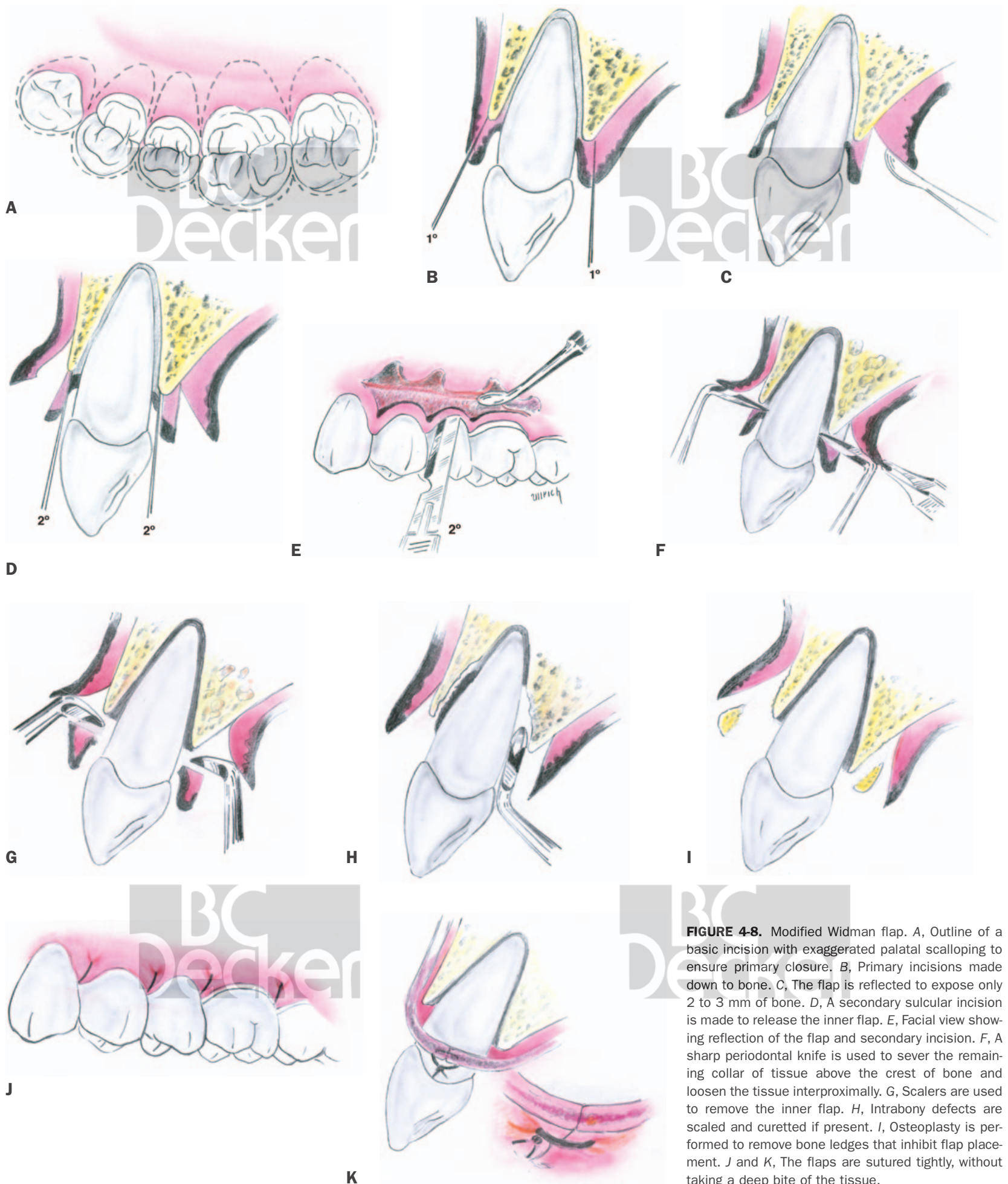




FIGURE 4-9. Modified Widman flap. *A*, Before treatment. *B*, Pretreatment radiographs showing moderate bone loss. *C* and *D*, Close-up view of buccal and palatal tissue. *E*, Initial scalloped incision with maximum conservation of interproximal tissue. *F*, Palatal view after initial incisions. *G*, Mucoperiosteal flap reflected with a horizontal cutting incision being made. *H*, Palatal view with the flap reflected. *I*, Removal of the secondary flap. *J*, Secondary inner flap removed and teeth sealed and root planed. Note that only 2 to 3 mm of bone has been exposed. *K* and *L*, Buccal and palatal views after completion of degranulation, scaling, and root planing. Note that maximum conservation of tissue will permit primary closure. *M* and *N*, Buccal and palatal views of completed interrupted suturing. *O*, Six weeks later. Note interproximal tissue craters. Courtesy of Giovanni Castellucci, Boston, MA.



FIGURE 4-10. Modified Widman flap. *A*, Before treatment, with the probe inserted, showing moderate to deep pocketing. Note also the enlarged edematous nature of the tissue. *B*, Scalloped incision outlined with maximum conservation of interproximal tissue. *C*, Initial primary crestal, inverse-beveled incision begun. *D*, Incisions completed. *E*, Secondary flap removed, scaling and curettage completed, and interproximal sutures placed. *F*, Ten months later; compare with *A*.



Gingivectomy and Gingivoplasty

Gingivectomy is the excisional removal of gingival tissue for pocket reduction or elimination. The technique has, as its main advantages, simplicity, and ease of mastery. Gingivoplasty is the reshaping of the gingiva to attain a more physiologic contour that allows a gradual rise of tissue interproximally and a fall on the labial and lingual surfaces. In gingivoplasty, the tissue is thinned interproximally to produce a more harmonious contour, with interproximal sluiceways for the easy passage of food. Gingivectomy and gingivoplasty are usually performed at the same time.

Rationale

1. Pocket elimination for root accessibility
2. Establish physiologic gingival contours

Indications

1. Suprabony pockets
2. An adequate zone of keratinized tissue
3. Pockets greater than 3 mm
4. When bone loss is horizontal and no need exists for osseous surgery
5. Gingival enlargements
6. Areas of limited access
7. Unesthetic or asymmetric gingival topography
8. For exposure of soft tissue impaction to enhance eruption
9. To facilitate restorative dentistry
10. To establish physiologic and gingival contours post-acute necrotizing ulcerative gingivitis and flap procedures

Contraindications

1. An inadequate zone of keratinized tissue
2. Pockets that extend beyond the mucogingival line
3. The need for osseous resection or inductive techniques
4. Highly inflamed or edematous tissue
5. Areas of esthetic compromise
6. Shallow palatal vaults and prominent external oblique ridges
7. Treatment of intrabony pockets
8. Patients with poor oral hygiene

Advantages

1. Predictability
2. Simplicity

3. Ease of pocket elimination
4. Good access
5. Favorable esthetic results

Disadvantages

1. Healing by secondary intention
2. Bleeding postoperatively
3. Loss of keratinized gingiva
4. Inability to treat underlying osseous deformities

Gingivectomy

Presurgical Phase

Presurgical preparation is carried out to reduce gross inflammation and remove local factors (calculus, plaque, or overhanging restorations). After initial healing, the zone of attached tissue can be assessed properly. At the time of operation, adequate local anesthesia is given. A vasoconstrictor should be used for control of hemorrhage, especially since healing is by secondary intention.

Under anesthesia, the pockets are probed to check their depth and to ensure that they do not extend beyond the mucogingival junction (Figure 5-1A). By sounding, the osseous topography is determined and the need for osseous surgery is determined (Figure 5-1B).

Gingivectomy is contraindicated if osseous surgery is needed.

Pocket Marking

A pocket marker or periodontal probe is used to outline the base of the pockets with a series of small bleeding points (Figure 5-1C). Three points (mesial, distal, and buccal) are marked on each buccal and lingual surface. These marks delineate the pocket wall to be removed.

The pocket marker is placed into the pocket and held parallel to the tooth. When the base of the pocket is reached, the tissue is marked (Figure 5-1D). Once the bleeding points have been established, they form a dotted line that outlines the incision. The pocket marker must not be tilted or the incision will be too deep or too shallow (see Figure 5-1D).

Incisions

Incisions may be continuous (Figure 5-1, E, H, I) or discontinuous (Figure 5-1, F, G). Both incisions are begun on the most terminal tooth and

are continued around until the incision is complete. No real differences exist between incisions except that one is an interrupted incision ending in the papillary area of each successive tooth until the incision is completed.

Incisions can be made with scalpels or gingivectomy knives, although the gingivectomy knife is easier to use because of the angulation and shape of the blade. The heel of the knife is used for the primary incision, which begins just apical to the bleeding points (Figure 5-1J). The blade is held in such a manner that the incision is as close to the bone as possible for total pocket removal and production of a tissue bevel of 45°. The blade must pass fully through the tissue to the tooth.

An Orban or Kirkland interproximal knife is used to free the tissue interproximally. It is placed interdentially at a 45° angle both buccally and lingually until the tissue is freed (Figure 5-1, K and L). The knife also engages the tooth to free the tissue at the line angle. If the incisions have been made properly, the tissue can be removed in one step. Figure 5-1M shows the correct and incorrect incision placements.

Once free, the tissue is removed by using a hoe or heavy scalers (Figure 5-1N). Small scalers and curets are now used for scaling and root planing to remove residual granulation tissue, calculus, and soft cementum (Figure 5-1O).

Gingivoplasty

The final contour of the tissue is established using scissors, tissue nippers, or diamond stones (Figure 5-1, P and Q). This final contouring, or gingivoplasty, is used to thin the tissue on the interradicular surface and establishes a more fluid contour. The healed tissue (Figure 5-1R) will be thin, with a scalloped architecture that flows smoothly from the interdental areas onto the interradicular surfaces for easy passage of food.

The complete procedure is outlined clinically in Figure 5-2, and the results that can be attained are shown in Figure 5-3.

Edentulous, Retromolar, and Tuberosity Areas

The edentulous area between the teeth is noteworthy only in that the incision should stretch the entire length of the space. Pockets tend to reform if the incision is limited to an area adjacent to the teeth (Figure 5-4).

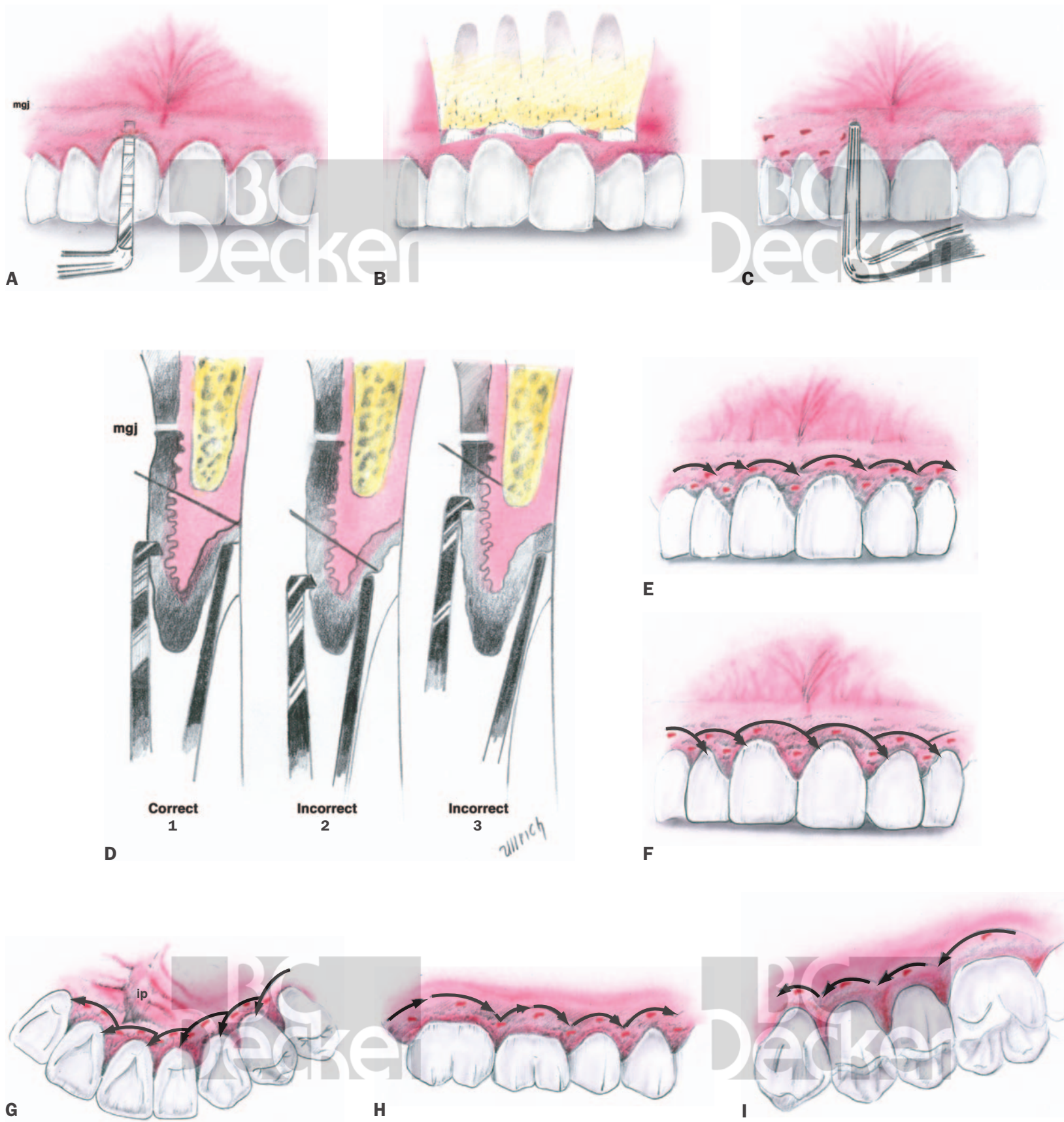


FIGURE 5-1. Gingivectomy technique. A, Enlarged gingival tissue with pocketing. B, Horizontal bone loss. C, Use of pocket markers to establish bleeding points for incisions. D, Correct and incorrect placement of pocket markers and how incisions are affected: 1 = correct marking with a beveled incision to the base of the pocket; 2 = incorrect shallow marking, resulting in incision above the base of the pocket; and 3 = incorrect deep incision, resulting in bone exposure and possible removal of all attached gingiva. E, Continuous incision on the buccal aspect. Note how incisions follow the outline of bleeding points. F, Discontinuous incision. G, Palatal incision. Note that the incisal papilla (ip) is outlined or avoided in this area. H, Continuous incision extending from the tuberosity area onto the buccal aspect of the teeth. I, Continuous incision on the palatal surface.



FIGURE 5-1. continued. *J*, Periodontal knife angulated at 45°, following the continuous incision outline. *K*, Interproximal knife used to separate and detach tissue buccolingually. *L*, Proper angulation of an interproximal knife to permit soft tissue coverage. *M*, Incision. 1 = correct incision beveled above bone to the base of the pocket; 2 = incorrect incision: there is no bevel and the incision is too deep, resulting in bone exposure; 3 = incorrect shallow incision, resulting in failure to remove the pocket; and 4 = incomplete incision because of failure to carry the incision to the tooth, resulting in ragged, torn tissue. *N*, Removal of excised tissue with a hoe or heavy scalers. *O*, Scalers and curets are now used to remove residual granulation tissue (1) and subgingival plaque and calculus (2). *P* and *Q*, Gingivoplasty is now completed using tissue nippers and diamond stones to establish a thin, even-flowing gingival architecture that has a scalloped outline rising interproximally to a conical shape. *R*, Final healed tissue.



FIGURE 5-2. Gingivectomy and gingivoplasty procedures. *A*, Before treatment. *B*, Bleeding points show marked pockets. Probe shows 4 to 5 mm pockets. *C*, Initial incision with a periodontal knife angled at 45°. *D*, A no. 15 scalpel blade used for the initial incision. *E*, Orban knife used to release interdental tissue. *F*, Heavy scalers used to remove incised tissue. *G*, Tissue removed. Note the ledge of beveled tissue. *H*, Scissors used for reduction of the ledge and gingivoplasty. *I*, Small diamonds are used to blend the tissue, especially interproximally on bulky tissue. *J*, Tissue nippers may be used for gingivoplasty. Note how tissue has been thinned and blended (*K*). *L*, Healed tissue 6 months later.



FIGURE 5-3. Results obtained by gingivectomy. A to D, Before. A' to D', After. Note how the teeth have come together in D'.

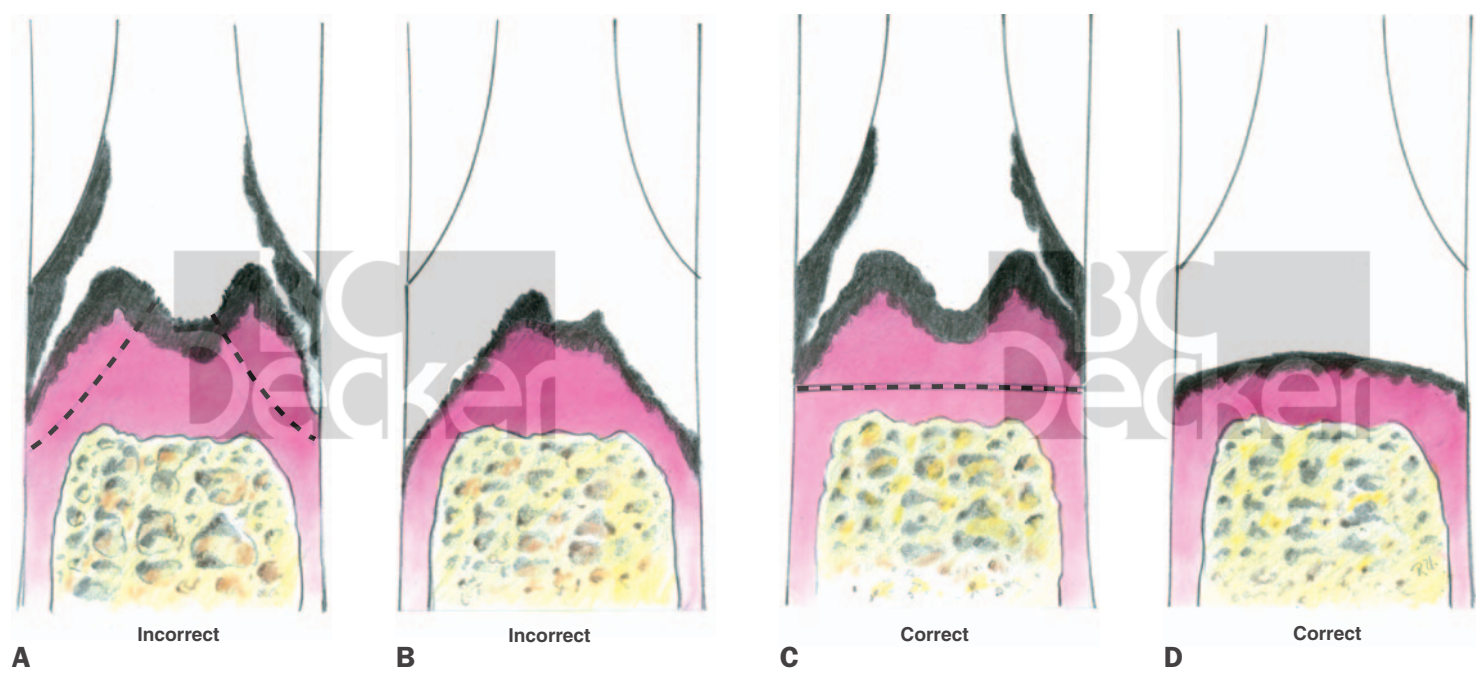


FIGURE 5-4. Treatment of edentulous areas. A, Outline of a correct incision to treat the total edentulous space. B, Healed ridge with no residual pockets. C, Incorrect incision, which treats only pockets adjacent to teeth. D, Residual pockets or depressions remain after treatment.

The retromolar (Figure 5-5) and tuberosity (Figure 5-6) areas are blended with the buccal and lingual (palatal) incisions. In the retromolar area, a gingivectomy is done only if there is adequate keratinized tissue distal to the tooth. The incision is flat or beveled to the base of the pocket.

Common Reasons for Failure

Wade outlined 15 reasons why gingivectomies fail, most of which are still valid today:

1. Unsuitable case selection: cases with underlying osseous irregularities or intrabony defects
2. Incorrect pocket markings
3. Incomplete pocket elimination
4. Insufficient beveling of the incision
5. Failure to remove tissue tags, resulting in excessive (granulation) tissue
6. Failure to remove etiologic factors—calculus and plaque
7. Beginning or terminating the incision in a papilla
8. Failure to eliminate or control the predisposing factors
9. Inaccessible interdental spaces
10. Loose dressings
11. Lost dressings
12. Insufficient use of dressings
13. Failure to prescribe stimulators or rubber tipping for interproximal use
14. Failure to use stimulators or a rubber tip
15. Failure to complete treatment

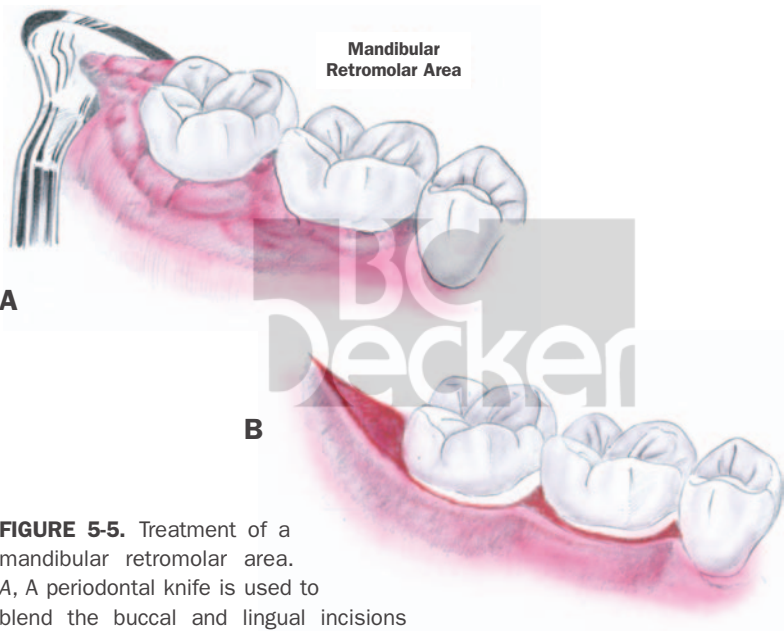


FIGURE 5-5. Treatment of a mandibular retromolar area. A, A periodontal knife is used to blend the buccal and lingual incisions about the distal aspect of the last molar if enough keratinized attached gingiva is present. B, Retromolar area reduced and blended with other incisions.

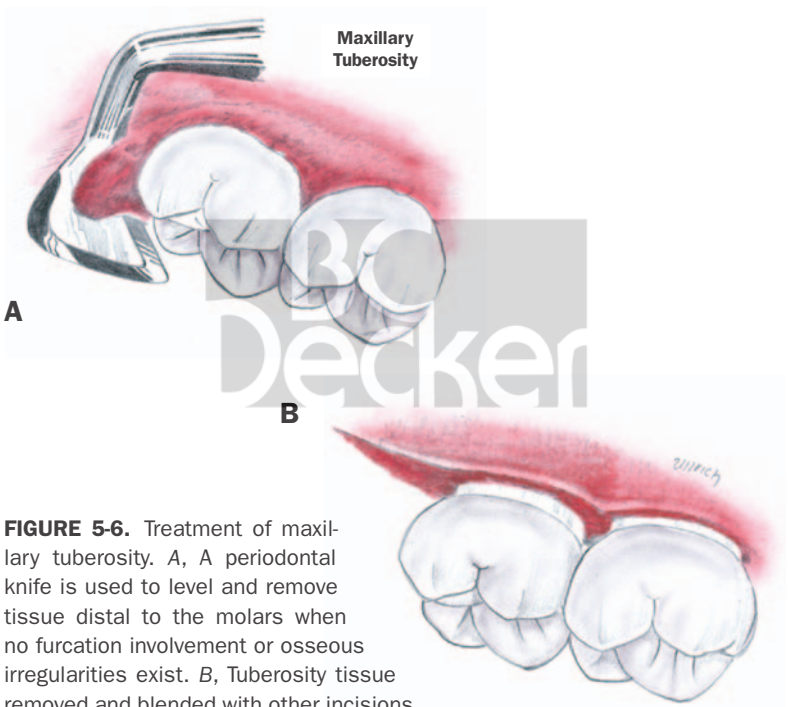


FIGURE 5-6. Treatment of maxillary tuberosity. A, A periodontal knife is used to level and remove tissue distal to the molars when no furcation involvement or osseous irregularities exist. B, Tuberosity tissue removed and blended with other incisions.

Mucogingival Surgery

Mucogingival surgical techniques are designed to provide a functionally adequate zone of keratinized attached gingiva (Friedman, 1962). These procedures, although not especially designed for pocket elimination or creation of proper physiologic form, may be combined with other procedures to obtain a healthy periodontal complex—a complex capable of withstanding the stresses of mastication, tooth brushing, trauma from foreign objects, tooth preparation associated with a crown and bridge, subgingival restorations, orthodontics, inflammation, and frenulum pull.

No standard width of keratinized attached gingiva has been established. In people with good oral hygiene, 1 mm or less may be sufficient for health (Lange and Loe, 1972; Miyasato and colleagues, 1977; Hangorsky and Bissada, 1980; de Trey and Bernimoulin, 1980; Dorfman and colleagues, 1980, 1982). Kirch and colleagues (1986), Wennström (1987), and Salkin and colleagues (1987) showed that even a movable marginal tissue of alveolar mucosa can be kept stable over a long period of time. Yet it may be necessary to increase this zone of healthy tissue if it is to be subjected to the trauma of prosthetic treatment (Maynard and Wilson, 1979; Ericsson and Lindhe, 1984), orthodontic restoration (Maynard and Ochsenbein, 1975; Coatoam and colleagues, 1981), or frenulum pull (Gottsegen, 1954; Corn, 1964a; Gorman, 1967) or in instances of rapidly progressing recession (Baker and Seymour, 1976; de Trey and Bernimoulin, 1980).

Tissue Barrier Concept

Goldman and Cohen (1979) outlined a “tissue barrier” concept for mucogingival surgery. They postulated that a dense collagenous band of connective tissue retards or obstructs the spread of inflammation better than does the loose fiber arrangement of the alveolar mucosa. They recommended increasing the zone of keratinized attached tissue to achieve an adequate tissue barrier (thick tissue), thus limiting recession as a result of inflammation. This view is indirectly supported by the findings of Kennedy and colleagues (1985) after recall evaluations of the unsupervised discontinued patients from their 6-year longitudinal study of free autogenous gingival grafts, as well as by the findings of Lindhe and

colleagues (1973), Baker and Seymour (1976), Rubin (1979), and Lindhe and Nyman (1980).

In contrast to these findings, teeth possessing the least attached tissue (cuspids and bicuspid) are the least involved periodontally, whereas the incidence of disease is greatest on the lingual and palatal surfaces, where the amount of keratinized tissue is greatest (Waerhaug, 1971). Furthermore, Wennström and colleagues (1981, 1982), Wennström and Lindhe (1983), and Kure and colleagues (1985) showed that a free gingival unit supported by a loosely attached alveolar mucosa is not more susceptible to inflammation than a free gingival unit that is supported by a wide zone of attached gingiva.

These procedures, therefore, should be used only where specifically indicated or where inflammation cannot be controlled. Wennström (1985) stated: “A thin marginal tissue, in particular in the absence of underlying alveolar bone, will be at greater risk of recession since the plaque-induced inflammatory lesion may occupy and cause destruction of the entire connective tissue portion of the gingiva.”

Hall (1977) noted several critical factors to be considered other than the mere lack of an adequate zone of attached gingiva:

1. Patient age
2. Level of oral hygiene
3. Teeth involved
4. Potential or existing esthetic problems
5. Existing recession with esthetic or sensitivity problems
6. The patient's dental needs
7. Previous dental treatment

General Considerations

Principles

1. Existing keratinized gingiva should always be maintained.
2. Exposing bone to increase the zone of keratinized gingiva is contraindicated (Wilderman, 1964).
3. When an adequate zone of attached keratinized gingiva exists, vestibular depth is not a factor (Bohannon, 1963a).

Objectives

1. To create an adequate zone of attached keratinized gingiva

2. To eliminate pockets that extend beyond the mucogingival line
3. To eliminate muscle and frenulum pull
4. To deepen the vestibule
5. To cover denuded root surfaces for esthetics or hypersensitivity
6. To overcome the anatomic factors of tooth position, thin alveolar housing, and large prominent roots, which promote dehiscence and/or fenestration formation with gingival accession
7. To minimize recession during orthodontic movement
8. To overcome the trauma of prosthetic restorative dentistry requiring subgingival placement
9. To stabilize and maintain a healthy mucogingival complex
10. To correct areas of progressive gingival recession
11. To correct ridge deformities and undercuts

Classification of Procedures

The surgical methods available for correction of mucogingival problems are as follows:

1. Periodontal flaps—positioned and repositioned
 - a. Full thickness (mucoperiosteal; modified, apically positioned)
 - b. Flap curettage
 - c. Partial thickness (apically positioned)
 - d. Curtain procedure
2. Free soft tissue autografts
 - a. Grafting for root coverage
 - b. Connective tissue pedicle graft
 - c. Ridge augmentation for esthetics
3. Subepithelial connective tissue graft
4. Laterally positioned pedicle flaps (partial and full thickness)
 - a. Edentulous ridge modification
 - b. Oblique rotated pedicle flap
 - c. Periosteally stimulated pedicle flap
 - d. Partial-full-thickness pedicle flap
 - e. Submarginal incisions
 - f. Coronally positioned flap
5. Double-papillae laterally positioned flap
 - a. Horizontal lateral sliding papillary flap
 - b. Rotated or transpositional rotated flap
6. Frenulectomy and frenulotomy

Periodontal Flaps—Positioned and Repositioned

Supraperiosteal Incisions

The periodontal flap, apically positioned or repositioned (unpositioned), full thickness (mucoperiosteal), or partial thickness (mucosal), is the most widely used technique in periodontics today. It is used to eliminate pockets, increase the zone of attached tissue, and relocate frenula. The full-thickness flap is used when osseous (resective or inductive) techniques are indicated. The partial-thickness flap is indicated for mucogingival problems and in areas where dehiscences or fenestrations may exist and bone must be protected (see Table 2-2).

Full-Thickness (Mucoperiosteal) Flap

The full-thickness flap procedure, as practiced today in periodontics, does not use a simple full-thickness flap but rather a partial-full-thickness flap. This is a result of the inverse-beveled incision described by Friedman (1964a), in which the marginal tissue and papillae are thinned or partially dissected by the initial incision.

This thinning incision eliminates thick gingival margins and papillae with large triangular pieces of interdental tissue. A thick tissue would be difficult, if not impossible, to trim properly once the flap has been raised and freed. Close approximation of the tissue to both tooth and bone would also be difficult, with a resultant bulbous or ledging-type tissues on healing.

Goldman and colleagues (1982) noted the use of a partial-full-thickness positioned flap or tertiary flap. The flap is identical to that already described except that once an adequate amount of bone has been exposed, sharp dissection is again employed. The advantage to this lies mainly in the ability to use periosteal sutures for proper flap positioning

Indications.

1. Pockets that extend beyond the mucogingival junction
2. Areas of minimal keratinized gingiva
3. Inductive or resective osseous surgery required
4. Enhance cleansability
5. Facilitate restorative procedures
6. Unesthetic or asymmetric gingival topography

Advantages.

1. Pocket elimination
2. Preservation of existing keratinized gingiva
3. Ability to perform inductive or osseous resective procedures
4. Relocation of frenulum
5. Primary intention healing
6. Access to roots for definitive scaling and root planing
7. Flaps can be positioned apically or coronally or unpositioned

Disadvantages.

1. Cannot be combined with other procedures to increase the zone of keratinized gingiva without exposure of bone
2. Moderate degree of difficulty
3. Should not be used in the presence of thin periodontium where dehiscences or fenestrations may exist
4. Apical positioning may increase root exposure and sensitivity and cause cosmetic and phonetic problems, especially anteriorly

Contraindications.

1. Esthetic considerations
2. Inadequate keratinized gingiva
3. Teeth having a poor prognosis: excessive mobility, a poor crown-to-root ratio, and advanced attachment loss

Incision Placement. Proper placement of the initial or primary inverse-beveled incision is critical when the amount of keratinized gingiva is limited. Friedman (1964a) classified incision placement based on the amount of keratinized attached tissue present.

Class I: keratinized gingiva is more than adequate; use of a *labial or buccal incision* placed 1 to 3 mm from the crest of the gingiva; the flap is apically positioned to cover 1 to 2 mm of cementum (Figure 6-1A)

Class II: keratinized gingiva is adequate; use of *crestal incision*; the flap is apically positioned to the crest of bone (Figure 6-1B)

Class III: keratinized gingiva; inadequate use of *sulcular incision*; the flap is apically positioned 1 to 2 mm below the crest of bone to increase the zone of keratinized gingiva (Figure 6-1C). **Note:** A **partial-thickness flap** is indicated here.

Procedure. With the patient under anesthesia, the area is probed to determine the pocket depth (Figure 6-2A) and underlying osseous topography (Figure 6-2B). The need for a full-thickness flap is indicated when pockets extend to or below the mucogingival junction and osseous surgery is needed.

Vertical incisions are used to outline the surgical site and are made at the mesial or distal line angles of the terminal teeth. These incisions should extend 3 to 4 mm into the alveolar mucosa and down to the bone to allow proper flap reflection.

A primary scalloped, inverse-beveled thinning incision is made 1 to 2 mm on the labial or buccal aspect of the gingival tissue (Figure 6-2C), thus preserving the remaining keratinized gingiva. In Figure 6-2D, the primary inverse-beveled incision is carried down to the crest of bone.

The papilla, because of its greater interproximal tissue bulk, must be thinned during the ini-

tial incision. If this is not done, the papilla will have a large triangular piece of tissue, which will make later close tissue adaptation difficult. Once free, the papilla is difficult, if not impossible, to thin properly. In Figure 6-2, E and F, the initial inverse-beveled incision partially dissects or splits the papilla, making it a partial-thickness flap.

A secondary incision is made about the necks of the teeth from the base of the sulcus to the crest of bone (Figure 6-2G and 2H). This loosens or frees the inner secondary flap, making removal of the tissue collar easier (Figure 6-2I).

The periosteal elevator is now placed at the terminal end of the flap, and while pressing against the bone, the flap is raised (Figure 6-2J). Once the flap is lifted off the bone, the elevator is directed from the side, *always pressing against the bone*, to raise the remaining portion of the flap.

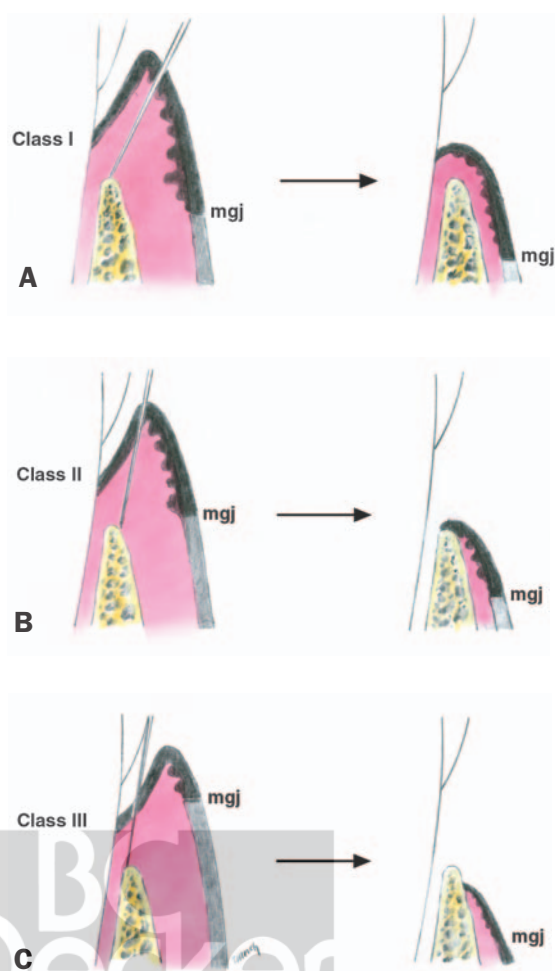


FIGURE 6-1. Classification of incision placement based on the presence of existing keratinized gingiva. A, Class I. More than adequate keratinized tissue; initial incisions buccal to the crest of gingiva and apically positioned to cover bone. B, Class II. Adequate keratinized tissue; initial incision at the crest of gingiva and flap positioned only to the crest of bone. C, Class III. Minimal or inadequate keratinized gingiva; sulcular incision and flap positioned apically to below the crest of bone to increase keratinized gingiva. **Note:** A **partial-thickness flap** is indicated here.

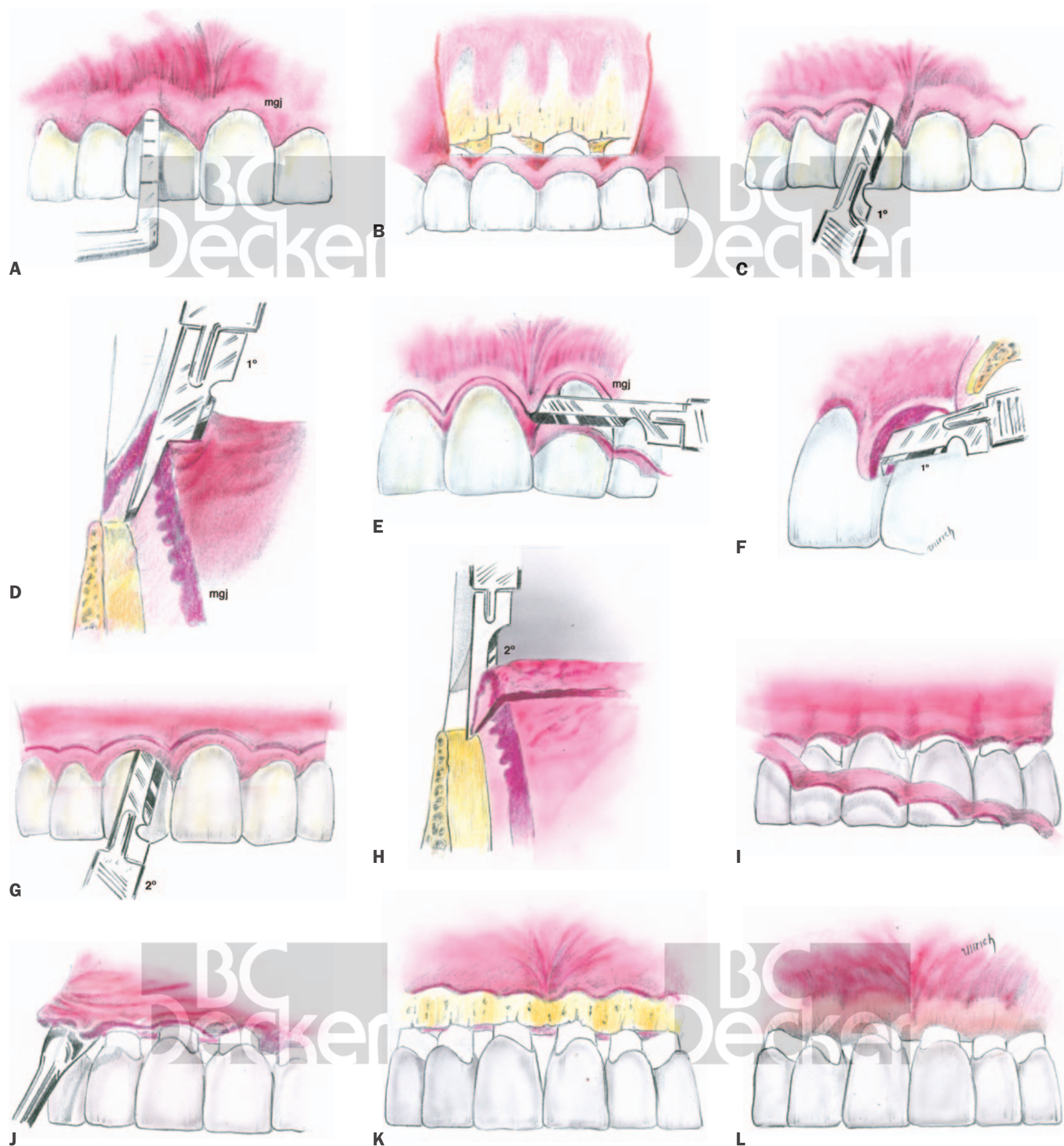


FIGURE 6-2. Full-thickness apically positioned mucoperiosteal flap. A and B, Deep pockets and bone loss with pockets probing to the mucogingival junction (mgj). C and D, Primary scalloped, inverse-beveled incision made down to the crest of bone. This primary incision thins the tissue. Vertical incisions are used to outline the flap. E and F, The papilla is dissected to create a partial-thickness flap and thus remove the thick triangular wedge of interproximal tissue. G and H, A secondary sulcular incision down to the crest of bone frees the inner flap of tissue. I, Scalars are used to remove the inner flap of tissue. J, The flap is raised with a periosteal elevator. K, Osseous resective measures are implemented. L, The flap is apically positioned to the crest of bone and sutured. Final healing is shown.

Tearing of the flap is common when a dull elevator is used or a sharp one is not maintained against the bone.

With the flap raised, scaling, root planing, degranulation, and osseous surgery are completed (Figure 6-2K).

The flap can be positioned apically or coronally or unpositioned, depending on the preference of the operator. Interrupted or continuous sutures may be used, although sling sutures permit better flap placement (Figure 6-2L). Pocket elimination is achieved only by apically positioning the flap.

The procedure is shown clinically in Figures 6-3 and 6-4.

Modified Apically Positioned Full-Thickness Flap

The modified flap procedure uses no vertical incisions. Although generally indicated for the posterior area as an extension of the distal wedge operation, the modified flap may be used anywhere.

Procedure.

- 1. The area is probed for pocket depth and underlying osseous topography (Figure 6-5A).
- 2. The primary incision is continued anteriorly from the distal wedge incision with a no. 15 scalpel blade (Figure 6-5B).

- 3. At the anterior extension of the flap, no vertical incision is made. Instead, the tissue is undermined and blended into the sulcus of the next tooth. A no. 15 scalpel blade is worked under the mucosal tissue on the facial aspect of the last tooth (Figure 6-5C). This permits adequate tissue drape so that a vertical incision becomes unnecessary. An adequate tissue drape may also be achieved by extending the flap one tooth beyond the surgical area.
- 4. After completion of the secondary incision, the flap is raised with a periosteal elevator and the secondary inner flap is removed with heavy scalers (Figure 6-5D).
- 5. The teeth are scaled and root planed, and osseous surgery is completed (Figure 6-5E).
- 6. The suturing is completed with continuous or interrupted sutures (Figure 6-5F).

The procedure is shown clinically in Figures 6-6 and 6-7.

Common Mistakes.

- 1. Figure 6-8A shows correct and incorrect placements for the incision. Incisions made over the radicular or facial surface may result in excessive bone loss with dehiscence or fenestration formation. The papilla should be taken full and not split, permitting greater ease of handling and suturing.

- 2. Figure 6-8B shows an inverse-beveled incision, which incorrectly removes all keratinized gingiva.
- 3. Figure 6-8C shows a poor flap design, with a narrow constricted base that may compromise blood supply and result in flap necrosis.
- 4. Figure 6-8D shows *mouse-holing*, which results from inadequate extension or release of the flap, limiting access and visibility and creating excessive tension at the margins.
- 5. Figure 6-8E shows excessive bone exposure because of poor flap adaptation, resulting in bone loss.
- 6. Figure 6-8F depicts poor suturing technique, resulting in the flap being pulled too high onto the enamel. This, in effect, replaces the pockets and causes a loss of the existing keratinized attached gingiva.

Flap Curettage

In 1976, Ammons and Smith outlined a technique for achieving reattachment and regeneration using a full-thickness flap for access and visibility to the roots for scaling and root planing. They further sought to maximize the existing periodontal support and, at the same time, reduce or eliminate periodontal pockets.

Flap curettage involves no more than an apically positioned full-thickness flap with or with-

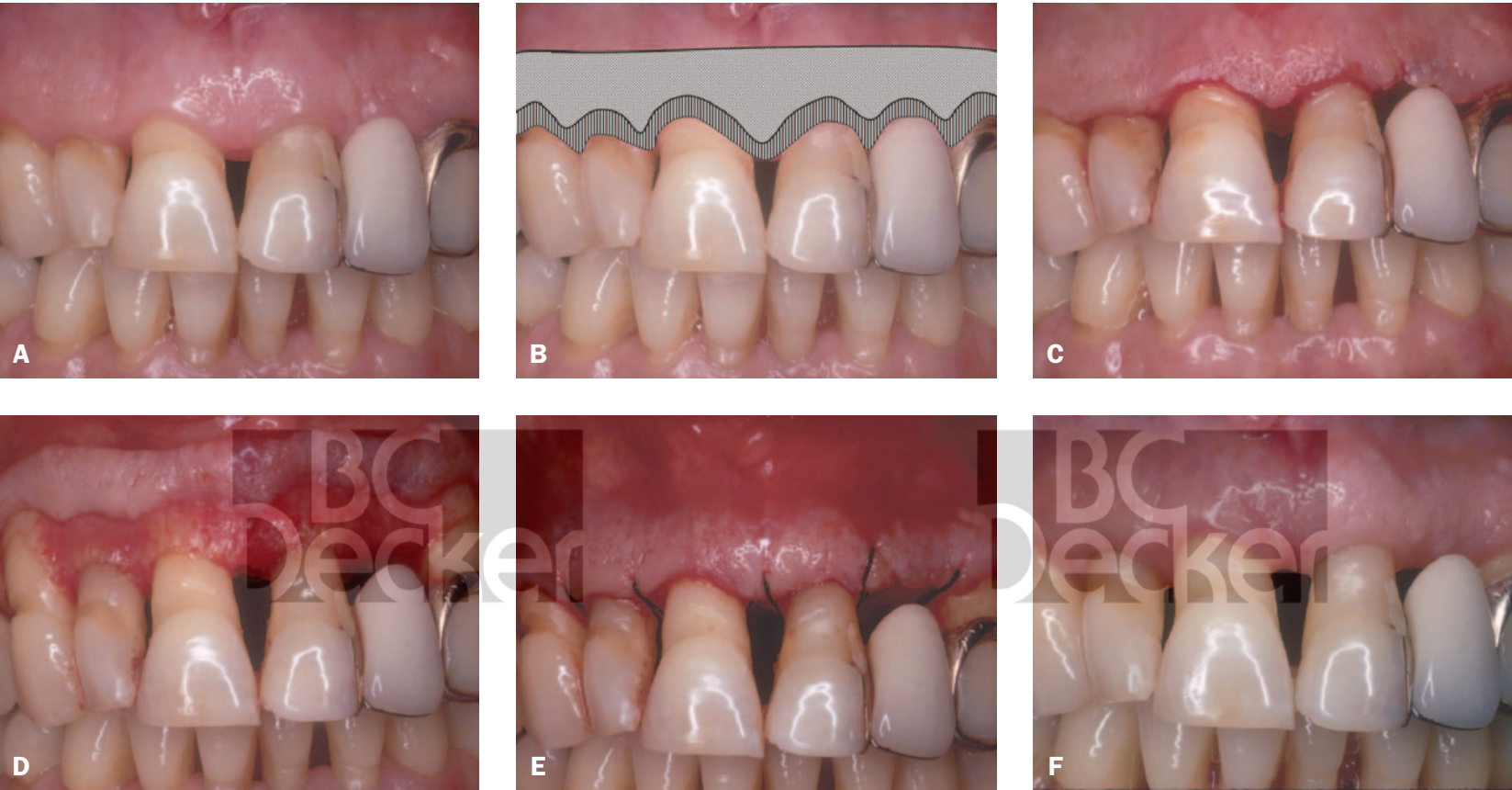


FIGURE 6-3. Apically positioned mucoperiosteal flap. A, Before. B, Incisions outlined: scalloped, inverse-beveled incisions and bilateral vertical incisions: primary (1°) and secondary (2°) flaps. C, Removal of a secondary inner flap. D, Flap reflected. E, Flap apically positioned. Vertical incision permits adequate apical positioning. F, Five months later. Note excellent contour and preservation of keratinized gingiva.



FIGURE 6-4. Apically positioned mucoperiosteal flap. A, Preoperative view. B, Crowns removed. Note short teeth. C, Initial scalloped incision. D and E, Mucoperiosteal flap reflected buccal and occlusal views. Note how the thin scalloped tissue allows the tissue to follow the final osseous contours. F, Osseous surgery completed. G, Buccal and occlusal views showing how vertical mattress sutures position tissue. H, Final prosthetics.

out vertical incisions. It includes thorough scaling, root planing, and débridement but no osseous surgery.

Olsen and colleagues (1985), in their 5-year review of apically repositioned flaps with and without osseous surgery, found that those areas treated with osseous surgery had significantly less bleeding and less postoperative pocketing. Neither treatment produced a gain in attachment.

Apically Positioned Partial-Thickness Flap

The technique for partial-thickness flaps uses a sharp dissection parallel to the bone, leaving a periosteal covering in an attempt to protect the underlying bone, eliminate pockets, reduce post-

operative pain, and shorten healing time (Ariau-do and Tyrell, 1960; Hileman, 1960).

Indications.

1. Areas of thin periodontium or prominent roots in which dehiscences or fenestrations may be present
2. A need to increase the zone of keratinized gingiva

Advantages.

1. Eliminate pockets
2. Protect underlying bone (ie, donor site of pedicle flap)
3. Can be combined with other mucogingival procedures to increase the zone of keratinized gingiva
4. Permit periosteal suturing for flap stabilization and exact positioning

Disadvantages.

1. Cannot be used for osseous surgery without resulting in a ragged, torn periosteum
2. High degree of difficulty to perform
3. Secondary intention healing

Procedure. Figure 6-9A depicts diagnostic probing and preoperative evaluation to determine the amount of keratinized gingiva and the presence of bony dehiscences or fenestrations (Figure 6-9B) prior to surgery.

A good rule of thumb to use in deciding whether a partial-thickness flap should be used is as follows: If the roots of the teeth can be palpated or visualized through the tissue, then a partial-thickness flap should be used. This ability to palpate the roots through the tissue has been termed

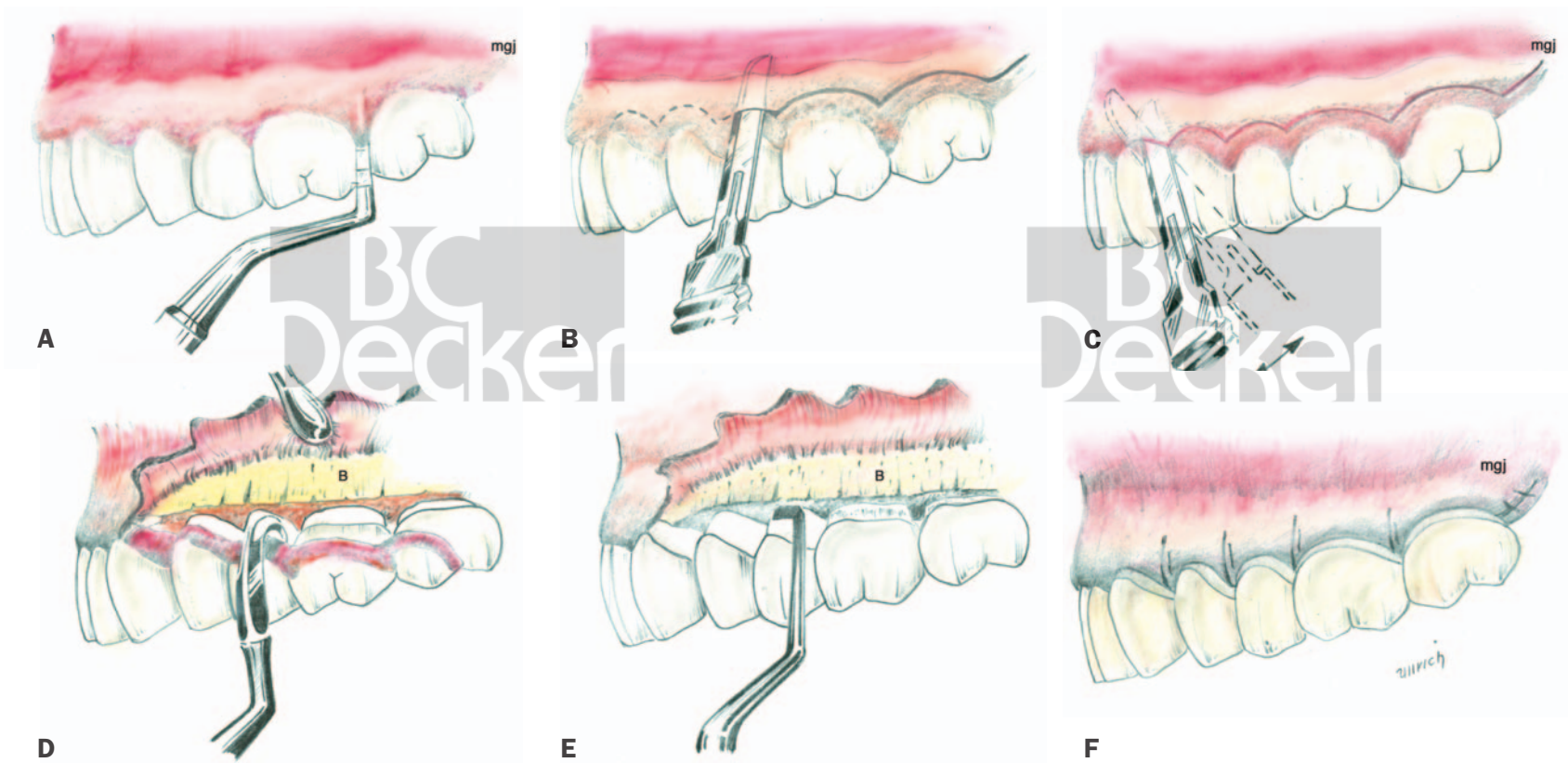


FIGURE 6-5. Modified flap procedure. A, Deep pockets probed at or below the mucogingival junction (mgj). B, A scalloped, inverse-beveled incision with no vertical incisions continued from the distal wedge. Maximum conservation of keratinized gingiva is attempted. C, For proper reflection, the flap is undermined at its most anterior extension. This permits adequate draping without the use of vertical incisions. D, The flap is reflected, and the secondary flap is removed. E, Scaling and osseous surgery are carried out. F, The flap is apically positioned and sutured.



FIGURE 6-6. Modified apically positioned mucoperiosteal flap. A, Before treatment. B, Primary scalloped, inverse-beveled incision to thin the tissue. C, Secondary or sulcular incision used to free the secondary or internal flap. D, Secondary flap removed. E, Flap reflected and osseous surgery completed. F, Flap positioned apically and sutured.

the washboard effect and is generally representative of a thin periodontium with underlying dehiscences or fenestrations.

With a no. 15 blade, two incisions are made: a straight vertical incision and a scalloped horizontal incision, neither of which is made down to the bone (Figure 6-9C). In Figure 6-9D, the scalpel blade is held parallel to the bone as the scalpel is moved apically toward the mucogingival junction. This provides the initial separation of the flap. The incision should maximize the maintenance of the existing keratinized gingiva.

Figure 6-9E shows how the remainder of the flap is sharply dissected. While applying gentle tension, the surgeon, using rat-tail tissue pliers, reflects the flap adjacent to the vertical incision

outward. A no. 15 scalpel blade is placed into the vertical incision and moved toward the mucogingival junction. The flap peels away from the underlying bound-down periosteum. The scalpel should always be kept in close proximity to the bone to prevent flap perforation.

Flap dissection should be carried out in an apico-occlusal direction, not in an occlusoapical direction (Figure 6-9F), because the tissue at the mucogingival junction is firmly bound down. This fact often results in flap perforation as a result of the scalpel blade accidentally slicing buccally instead of moving apically when dissection is attempted from the occlusal direction.

The gingival tissue above the crest of bone is removed by first making an incision perpendicu-

lar to the teeth with a gingivectomy knife or no. 15 scalpel blade (Figure 6-9, G and H) and then using sharp scalers and curets, making sure to leave the fibers at and just above the bony crest intact (Figure 6-9, I and J).

Periosteal sutures (4-0 or 5-0 silk or gut) are used to stabilize and position the flap (Figure 6-9, K and L).

The zone of attached gingiva can be increased by apically positioning the flap below the crest of bone. The amount of keratinized attached gingiva gained this way is unpredictable and will generally be equal to about 50% of the exposed area.

The procedure is shown clinically in Figures 6-10 to 6-14.



FIGURE 6-7. Modified apically positioned flap. A, Before treatment. B, Primary scalloped, inverse-beveled incision to thin tissue. Note: Submarginal incision placement due to wide zone of keratinized gingiva. C, Primary flap reflected. D, Secondary flap is reflected, and area is scaled and débrided. E, Osseous surgery completed. **Note: Osseous surgery was compromised owing to furcation proximity.** F, Vertical mattress periosteal continuous sling suture. G, Four years later. Note excellent adaptation and maintenance of tissue contours.

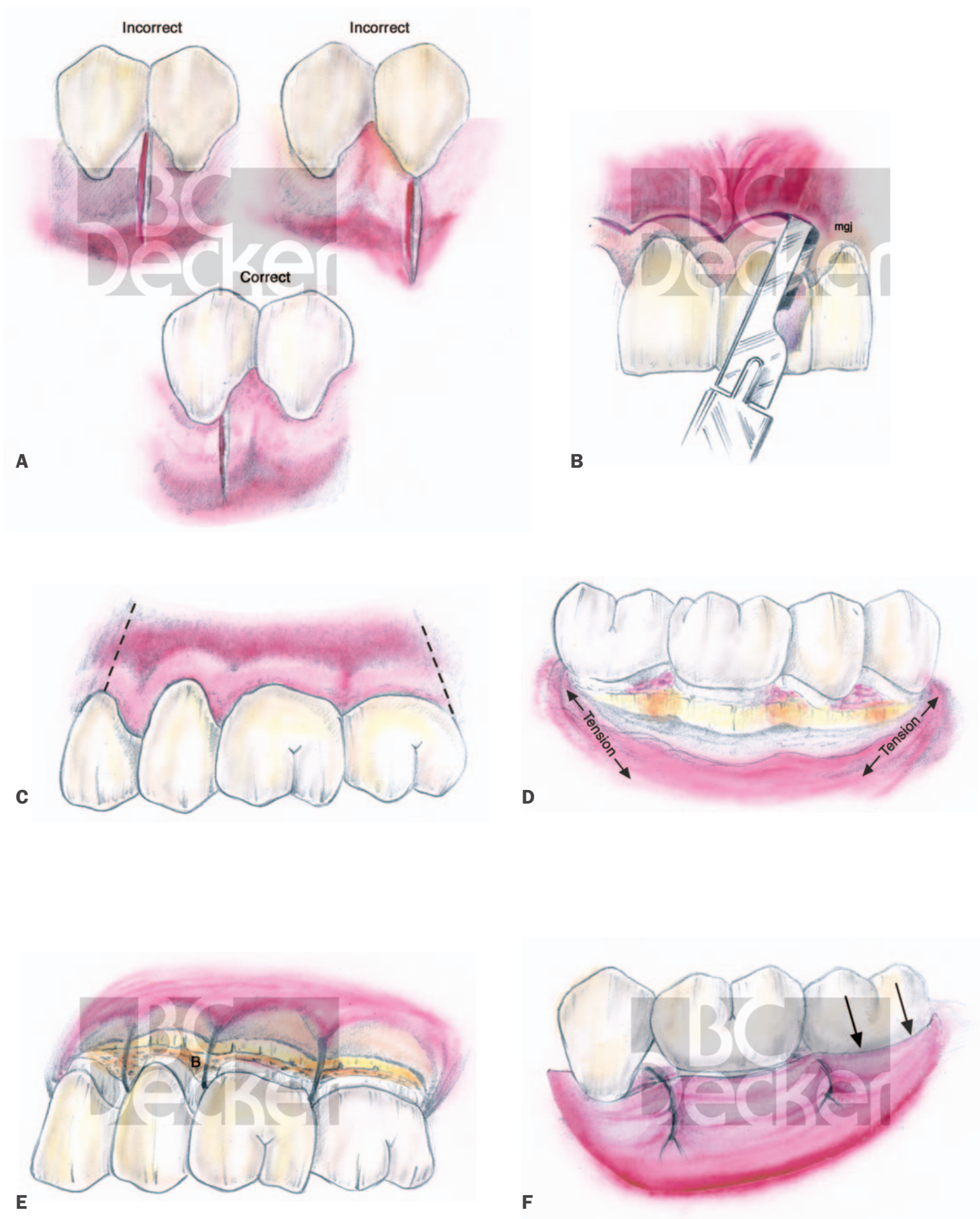


FIGURE 6-8. Mistakes in flap design. *A*, Correct and incorrect placement of vertical incisions. Vertical incisions are always made at the line angles of the teeth and include the full papillae, not on the facial surface but in the middle of the papillae. *B*, Initial inverse-beveled incision removes all attached gingiva. *C*, Vertical incisions make the base of the flap too narrow and may compromise blood supply. *D*, Excessive tension is placed on the flap because of poor extension. *E*, Excessive bone exposed owing to the drop of the flap. *F*, Flap pulled too high onto the tooth, replacing pockets.

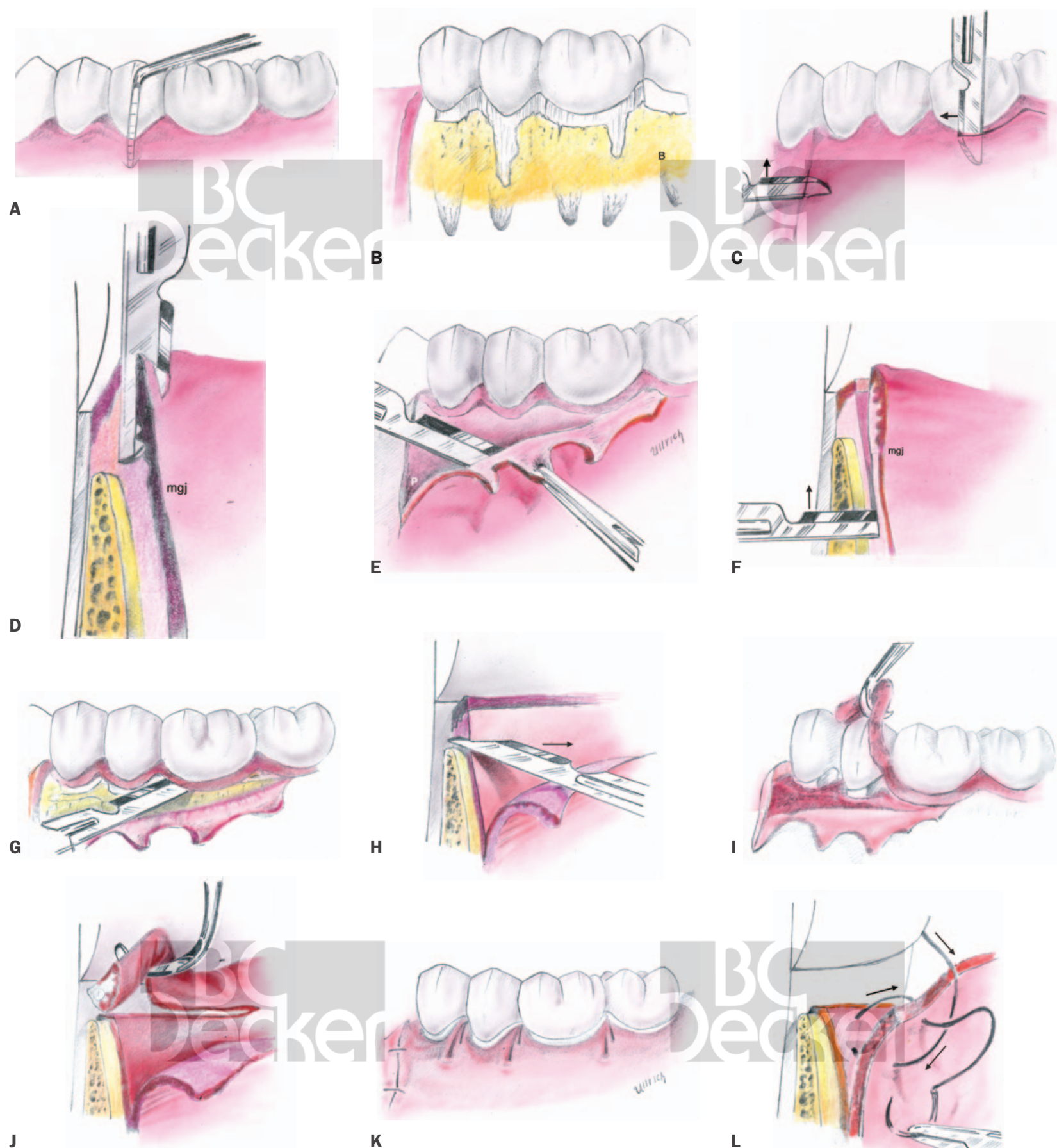


FIGURE 6-9. Partial-thickness flap. *A*, Minimum amount of attached keratinized tissue present; ability to probe beyond the mucogingival junction. *B*, Cutaway showing thin periodontium with dehiscences and fenestrations. *C*, Initial vertical incision and horizontal incisions are made. *D* shows that incisions are not made down to bone. *E* and *F*, The flap is dissected from an apico-occlusal direction as tension is applied to the flap with tissue pliers. *G* and *H*, A horizontal incision is made just above the crest of bone to permit removal of the inner flap. *I* and *J*, Scalers and curets are now used to remove the inner flap and residual granulation tissue. *K* and *L*, Periosteal sutures permit exact flap placement at or below the crest of bone. A more apical placement is used if necessary to increase the zone of attached gingiva.

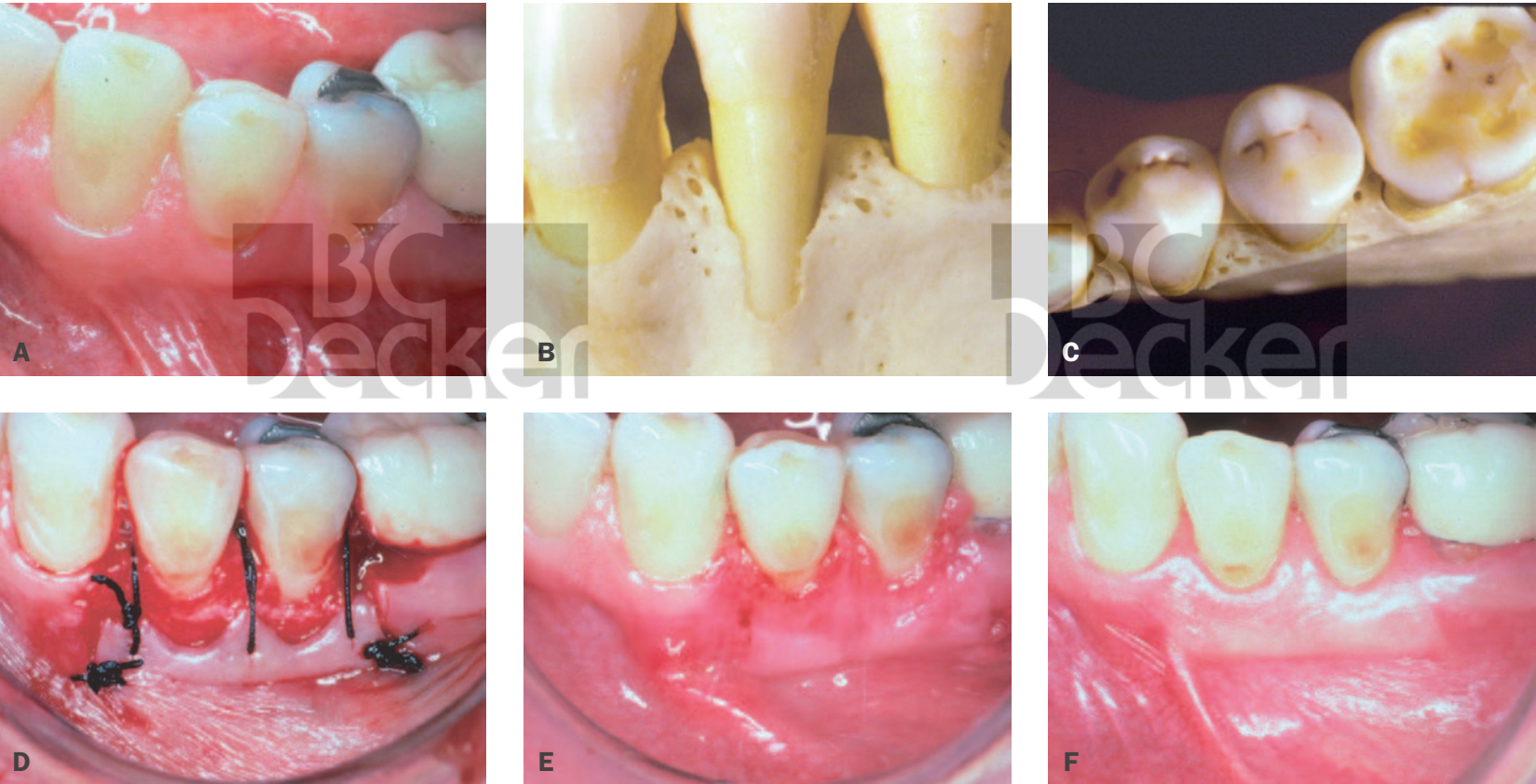


FIGURE 6-10. Apically positioned partial-thickness flap. A, Before treatment. B, Partial-thickness flap apically positioned by simple suspensory suture. C, One week later. D, Two months later. Note apical displacement of the mucogingival junction (E) and increased zone of keratinized gingiva (F).

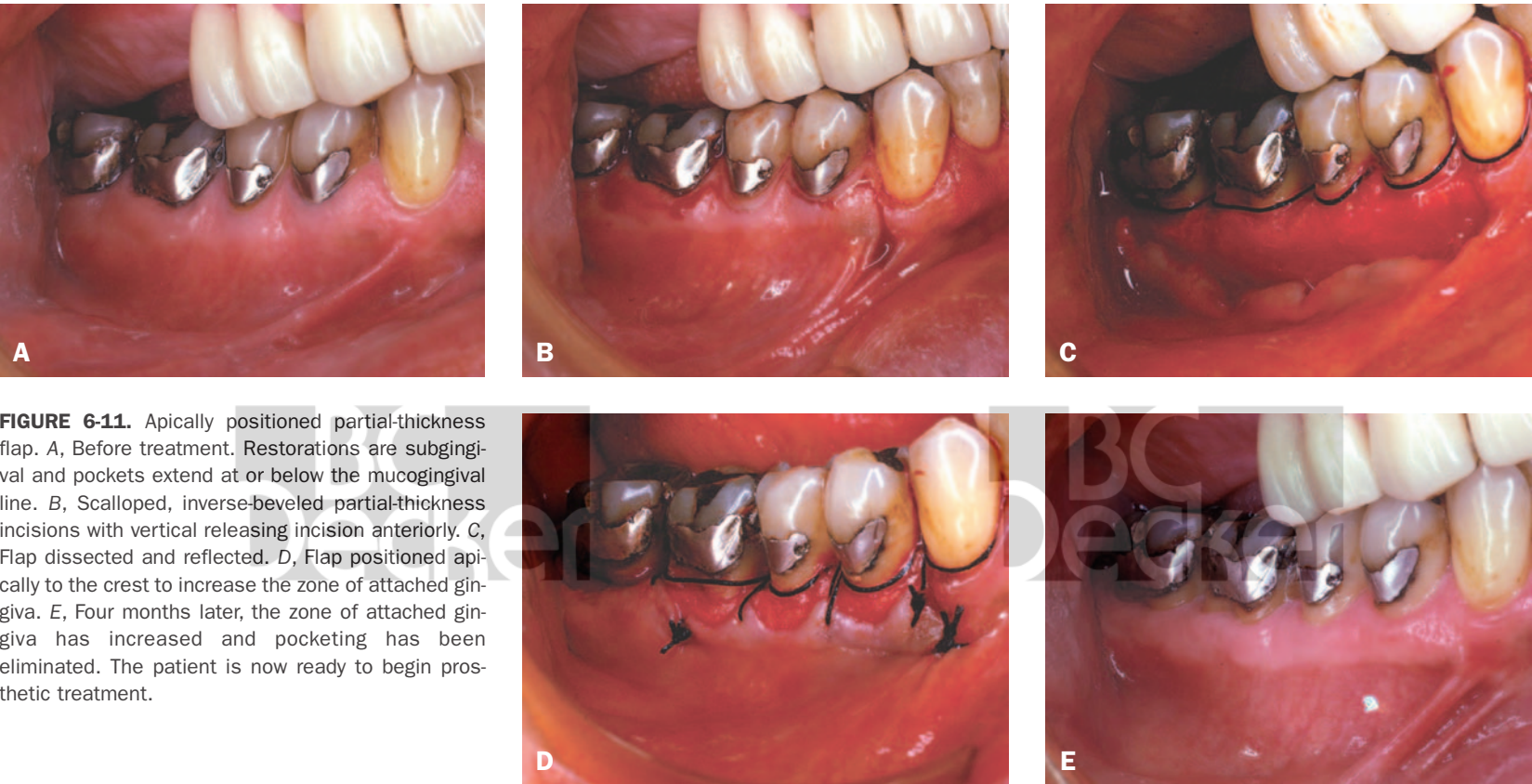


FIGURE 6-11. Apically positioned partial-thickness flap. A, Before treatment. Restorations are subgingival and pockets extend at or below the mucogingival line. B, Scalloped, inverse-beveled partial-thickness incisions with vertical releasing incision anteriorly. C, Flap dissected and reflected. D, Flap positioned apically to the crest to increase the zone of attached gingiva. E, Four months later, the zone of attached gingiva has increased and pocketing has been eliminated. The patient is now ready to begin prosthetic treatment.



FIGURE 6-12. Apically positioned partial-thickness flap for crown lengthening prior to prosthetics. *A*, Before treatment. Note that the margins are subgingival and the attached gingiva is inadequate. *B*, Partial-thickness flap positioned apically to the crest of bone to increase the zone of attached gingiva. *C*, Occlusal view showing the mucoperiosteal flap on the lingual aspect for osseous correction of small defects and pocket elimination. *D*, Temporary bridge replaced. Note adequate tooth structure visible below the crown margins. Adequate biologic width established. *E* and *F*, Six months later, the case is complete. Note open embrasures and margins at or above the gingival crest. Prosthetics courtesy of Dr. Bernard Croll, New York.



FIGURE 6-13. Apically positioned partial thickness flap for crown lengthening and increasing the zone of keratinized gingiva. *A*, Initial composite view showing thin gingival tissues with minimal or no keratinized gingiva. *B*, Partial or split thickness flap. *C*, Flap apically positioned and sutured with continuous periosteal sling sutures facially and lingually. *D*, Final case one year later. Note a thicker gingival tissue with a wide zone of keratinization. Compare to *A*. Prosthetics courtesy of Dr. Richard Harrison, Bridgewater, MA.

FIGURE 6-14. Partial thickness flap for implant exposure and increasing the zone of keratinized gingiva. A, Facial view showing minimal zone of keratinized gingiva. B, Occlusal view showing outline of partial thickness incision on palatal aspect of ridge for preservation of keratinized gingiva. C and D, Buccal and occlusal views of partial thickness flap for increasing the zone of keratinized tissue positioned and sutured. E and F, Buccal and occlusal views of final heading. Note significant gains in keratinized gingiva. Compare to A and B. G, Final prosthetic case. Prosthetics courtesy of Dr. Richard Russman, Randolph, MD.



Free Soft Tissue Autograft

The free soft tissue graft is the most widely used, most predictable technique for increasing the zone of attached gingiva. It is a highly versatile procedure, with such unlimited potential, either solely or in conjunction with other procedures, that there is a tendency to overuse it. It is simple enough, while requiring a moderate degree of technical expertise, which is within the scope of the general dentist.

Historical Background

Published reports on gingival grafting began appearing in the American literature in the 1960s (Bjorn, 1963; King and Pennel, 1964; Cowan, 1965; Nabers, 1966b; Haggerty, 1966). Yet it was not until Sullivan and Atkins (1968) published

their classic trilogy of articles on indications, techniques, and wound healing and grafting that grafting became popular. So complete were their articles that, with the exception of certain modifications, the principles and techniques outlined then are still valid today:

1. Gargiulo and Arrocha (1967) used gingivectomy tissue as donor tissue.
2. Sullivan and Atkins (1968) published classic articles on the free gingival graft technique.
3. Pennel and colleagues (1969) developed the submarginal technique and supplemental combined use of periosteal fenestration.
4. Karring and colleagues (1972, 1974) showed that the connective tissue determines the nature of graft tissue and described the use of connective tissue autografts.

5. Dordick and colleagues (1976) placed grafts directly on bone for a firmer attachment.
6. Carvalho and colleagues (1982) used a periosteal pedicle as an aid in root coverage.
7. Holbrook and Ochsenbein (1983) demonstrated a refined suturing technique for root coverage.
8. Ellegaard and colleagues (1974) used free gingival grafts to retard epithelial migration over osseous grafts.

Advantages

1. High degree of predictability
2. Simplicity
3. Ability to treat multiple teeth at the same time
4. Can be performed when keratinized gingiva adjacent to the involved area is insufficient

5. As the first step in a two-stage procedure for attaining root coverage
6. As a single step for attaining root coverage

Disadvantages

1. Two operative sites
2. Compromised blood supply
3. Lack of predictability in attempting root coverage
4. Greater discomfort
5. Poor hemostasis
6. Retention of graft

Procedure

Preparation of Recipient Site. Anesthesia is obtained by local infiltration with a 30-gauge needle using 1:100,000 epinephrine. Concentrations of 1:50,000 are generally unnecessary unless hemostasis is a problem. Furthermore, in giving anesthesia, an attempt should be made not to distort the mucosal tissue with excessive anesthetic, which may make preparation of the recipient site more difficult.

The surgical site is carefully examined to determine whether root coverage will be attempted. If root coverage is to be attempted, then epithelial denudation of the marginal and papillary tissue is necessary. If not, then only a submarginal incision is used.

Figure 6-15A shows a tooth with gingival recession and a minimal amount of attached tissue. Figure 6-15B gives a cross-sectional view of the same areas.

Prior to making the first incision, tension is placed on the tissue by retracting the lip or cheek. This retraction (Figure 6-15, C and D) generally lifts the mucosal tissue off the bone and up to or near the mucogingival junction. This is made possible by the loose underlying alveolar submucosal tissue.

A no. 15C scalpel blade is used to make the first incision while the tissue is still being retracted. The incision is usually begun at the distal end of the surgical site, with the blade held nearly parallel to the alveolar process. A small stab incision is made at or just below the mucogingival junction (Figure 6-15, E and F). The mucosal tissue immediately separates and retracts as a combined result of the tension and loose elastic nature of this tissue. The blade continues to be drawn in a mesial direction for the full length of the incision (Figure 6-15G).

Once the incision is completed, sharp dissection with the scalpel blade is continued apically to separate the remaining alveolar mucosa from the firmly bound-down periosteum. The periosteal bed would be overextended in an occlusoapical direction to compensate for primary and secondary shrinkage of the graft during healing. It is generally extended 6 to 8 mm except

where anatomically limited (eg, by the mental nerve, external oblique ridge, or zygomatic arch).

An alternative method for preparation of the recipient site uses small vertical incisions to outline the surgical area. The vertical incisions are then connected with a horizontal incision at the mucogingival junction. Often the mucosal flap is sutured at the base of the vestibule.

In the mandibular bicuspid area, special care must be given to preventing damage to the mental nerve. For this reason, LaGrange curved scissors are sometimes recommended for separating the alveolar connective tissue and reflecting the mucosa. Visualization of the branches of the mental nerve through tissue will limit apical extension of the bed.

Figure 6-15H shows the mucosal flap reflected with a submarginal incision. A small band of alveolar mucosa is still present between the periosteal bed and the keratinized attached gingiva. If this is not removed, a red band of bound-down alveolar mucosa will be permanently established between new and old tissue (see Figure 6-15E). Scissors or tissue nippers may be used to remove this residual band of alveolar mucosa (Figure 6-15I). In Figure 6-15J, the final blending of tissue up to the mucogingival junction is complete.

In Figure 6-15K, scissors are used to remove all residual muscle and connective tissue fibers from the periosteal bed. A periodontal knife may also be used in a pushing motion apically to remove fiber and extend the periosteal bed apically. High-speed, round diamond stones or tissue nippers (see Figure 6-15K) are used to complete the epithelial denudation if this is desired. Some epithelial denudation is desirable to allow some overlap of the graft and keratinized tissue even if root coverage is not a primary goal.

Even though suturing the mucosal flap apically is unnecessary, it is often done for hemostasis and greater stability. Chromic gut sutures are recommended for apical suturing because tissue overgrowth is common at 1 week, making removal of sutures difficult. Suturing can be interrupted or continuous.

The final step is determining graft size. This is best accomplished with a tinfoil template cut to the correct size and shape and fitted first at the recipient site (Figure 6-15L). A periodontal probe can also be used once familiarity and confidence with the technique are developed.

A moistened saline sponge is placed over the recipient bed for hemostasis and protection.

Preparation of Donor Tissue. Site selection and thickness of donor tissue will vary according to the individual operator's preference and the intended purpose and function of the graft tissue.

Graft Thickness. Graft thickness was originally outlined and classified by Sullivan and Atkins

(1968a,1968b), who also determined the viability of the graft and its ability to withstand functional stress. Figure 6-16 shows the various thicknesses of palatal tissue they outlined. It is not generally accepted that a thin or intermediate-thickness graft is best for increasing the zone of keratinized attached gingiva, whereas a thick or full-thickness graft is recommended for root coverage and ridge augmentation procedures.

Thin or intermediate-thickness grafts of approximately 0.5 to 0.75 mm are the ideal thickness for increasing the zone of keratinized attached gingiva (Soehren and colleagues, 1973) and at the same time producing a result that is esthetically pleasing. Grafts of this thickness undergo minimal primary contraction because of the small amount of elastic fibers (Orban, 1966).

On the other hand, they do undergo a good deal of secondary contraction of approximately 25 to 45% (Ratertschak and colleagues, 1979; Seibert, 1980; Ward, 1974) as a result of cicatrization, which binds the graft to the underlying bed (Barsky and colleagues, 1964). This shrinkage can be compensated for by making the graft appropriately wider at the time of operation.

Thick or full-thickness grafts of 1.25 to 2 mm or greater are indicated for root coverage and ridge augmentation procedures. They are thick enough to sustain themselves over avascular root surfaces while thinning without splitting until the plasmatic diffusion can be effective. They also tend to create an unesthetic patch-like graft; they have greater primary contraction owing to the large amount of elastic fibers (Davis and Kitlowski, 1931) but minimal secondary contraction because of the thicker lamina propria (Barsky and colleagues, 1964). The greater primary contraction tends to delay revascularization by closing down the blood vessels (Davis and Davis, 1966).

Obtaining Graft Tissue. Donor tissue, although obtainable from various sites—the edentulous ridge, the tuberosity area, gingivectomy tissue—is most often secured from palatal tissue. The area of choice is the gingival zone distal to the anterior ruga on the posterior portion of the palate (Figure 6-15M). This has the widest gingival zone with the least amount of submucosa (Figure 6-15N). The submucosal tissue is fatty anteriorly and glandular posteriorly.

If excessive fat or glandular tissue is taken as part of the graft, it may inhibit graft take by reducing plasmatic diffusion. This is usually not a problem with thin or intermediate-thickness grafts of 0.5 to 1 mm, but with thicker grafts of 1.5 to 2 mm, which are used for root coverage, it may present a problem. On the other hand, Miller (1985b) advocated leaving a thin submucosal layer to ensure adequate thickness and theorized that it may act as a barrier to the cells of the periodontal ligament and increasing potential

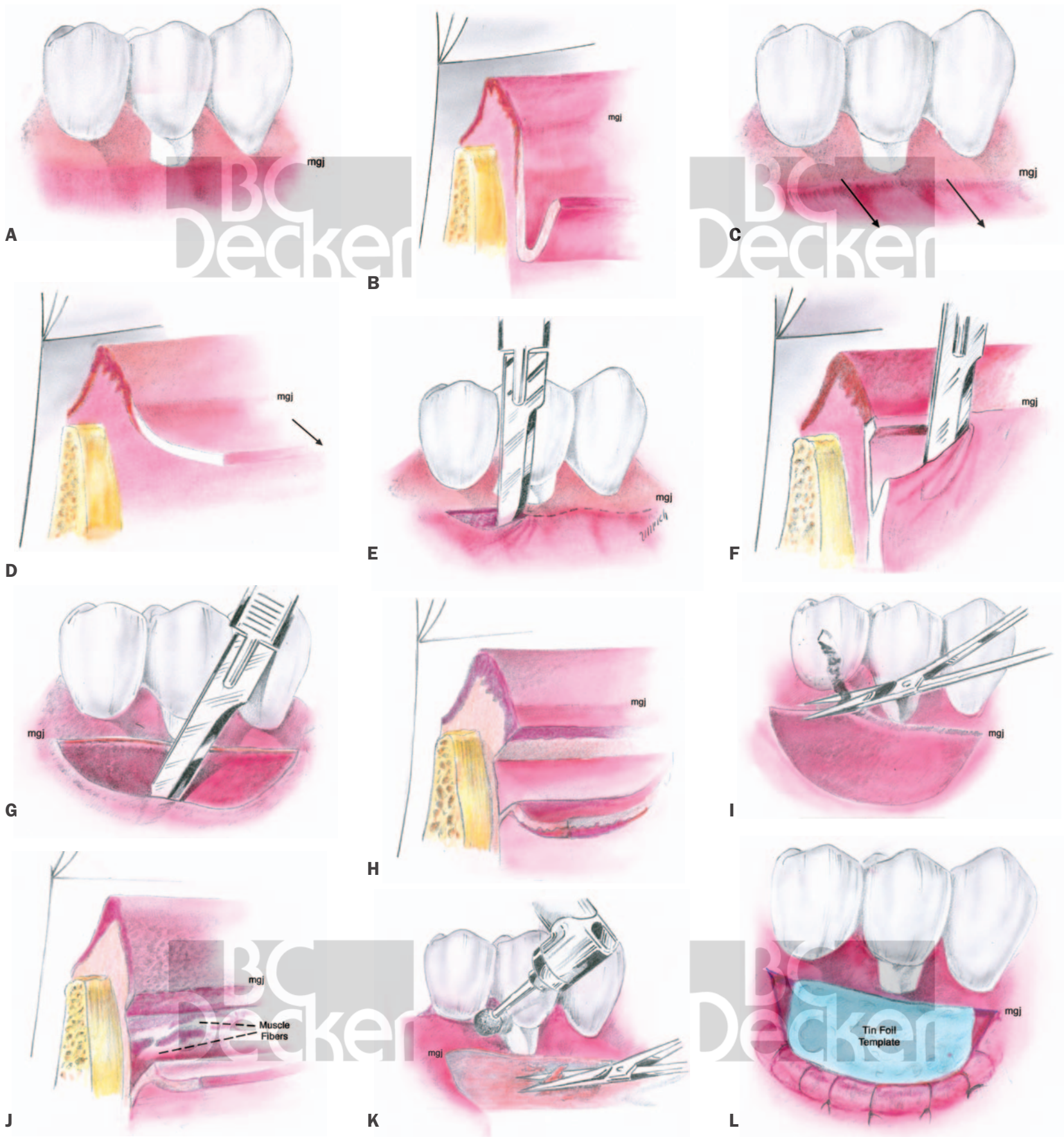


FIGURE 6-15. Free soft tissue autograft. A, Preoperative view showing recession and lack of attached keratinized gingiva on a bicuspid. B, Cross section of a bicuspid with recession and lack of attached gingiva. C and D, Facial and cross-sectional views display the effects of tension applied to tissue. Note that the tension raises the mucosal tissue off the bone. E and F, Initial stab incision just at or below the mucogingival junction (mgj) with the blade held parallel to the bone. G, Continuation of incisions both horizontally and apically. H, Cross section showing tissue reflected, leaving a periosteal bed. I, Removal of residual alveolar mucosa at the mgj. J, Cross section shows blending of a prepared periosteal bed with coronal attached gingivae and removal of residual alveolar mucosa. K, Final removal of muscle and connective tissue fibers from the periosteal bed as well as blending as incisions. L, Tinfoil template used to help establish the size of donor tissue.

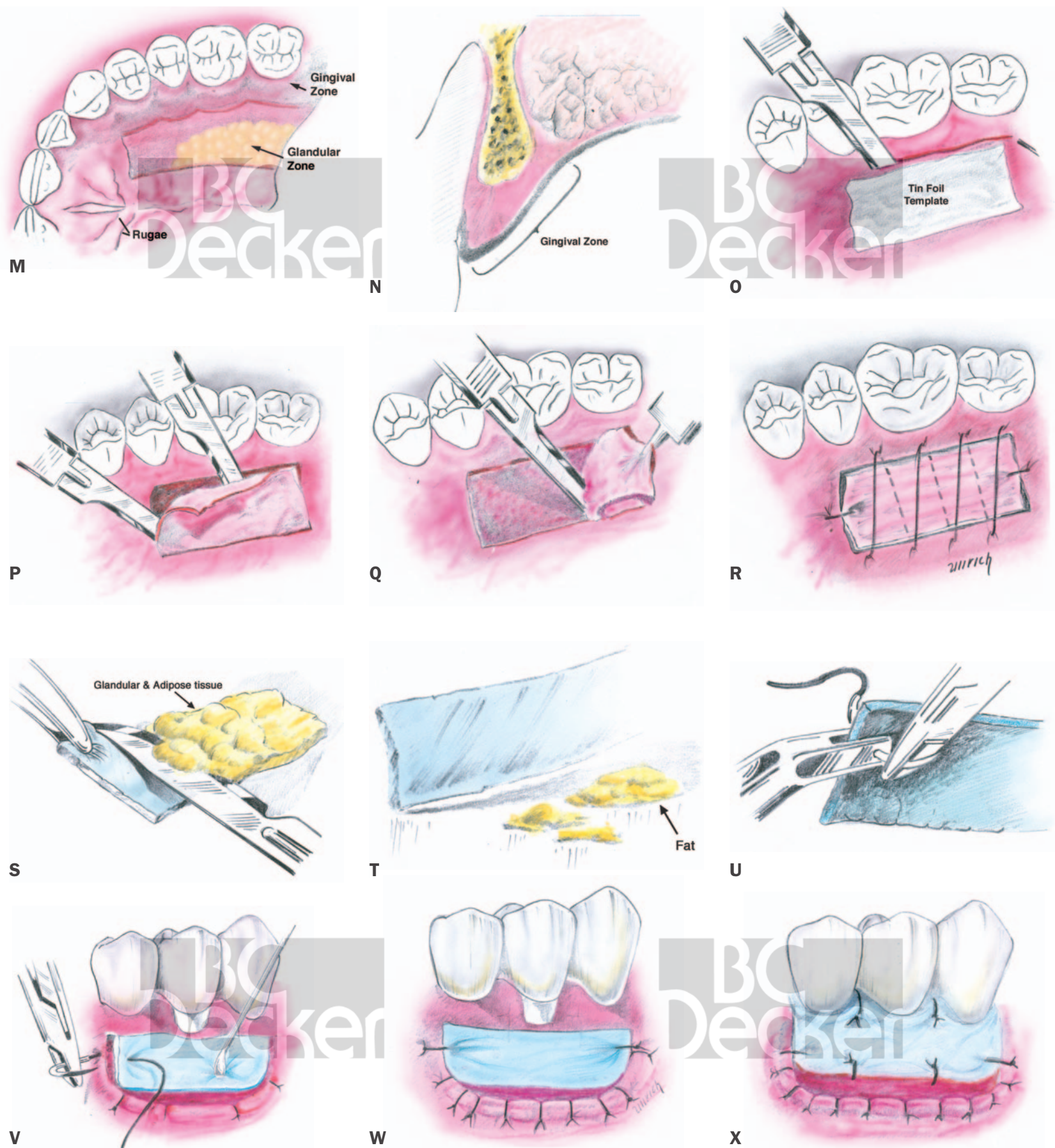


FIGURE 6-15. Continued. *M* represents various zones of palate from which donor material may be selected. *N*, Cross-section enlargement of the posterior gingival zone from which material is usually selected. *O*, Outlining of the graft from a previously sized tinfoil template. *P*, Partial-thickness dissection of the graft. *Q*, Use of tissue pliers to reflect graft tissue as it is being dissected. *R*, Graft removed and palate sutured for hemostasis. *S*, Use of a sharp scalpel blade to remove any fat or glandular tissue and to reduce underlying tissue irregularities. *T*, Graft smoothed. *U*, Initial suture placed in the graft. *V*, Stabilization of the graft during the suturing phase. *W*, Graft placed below recession and sutured in position. Note the apical suturing or mucosal flap, which is optional. *X*, Coronal positioning for root coverage.

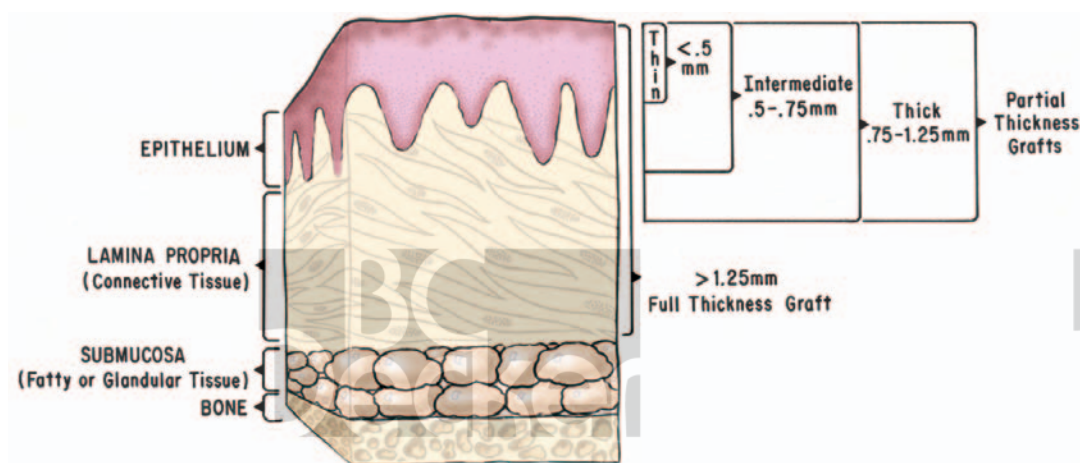


FIGURE 6-16. Diagrammatic representation of palatal tissue. Illustration of partial- and full-thickness soft tissue grafts of various thicknesses.

root coverage. As shown in Figure 6-15O the palate has been anesthetized with lidocaine 1:50,000 for control of pain and hemorrhage. The tinfoil template is placed close to the marginal area and outlined with a no. 15 scalpel blade.

The incision is begun along the occlusal aspect of the palate with a no. 15 scalpel blade held nearly parallel to the tissue. A beveled access incision (Sullivan and Arkins, 1968a) is sometimes recommended for achieving the desired graft thickness. Once the incision on the occlusal aspect is complete, the blade is continued apically, lifting and separating the graft as it moves through the tissue toward the apical border. *Note that, in directing the blade apically, special care should be given to maintaining an even thickness and not taking too deep a wedge.*

It is necessary to release the most anterior vertical incision prior to detaching the graft apically (Figure 6-15P). Once that is done, tissue pliers are used to retract the graft distally as it is being separated apically and dissected, until the graft is totally freed (Figure 6-15Q).

The freed graft is placed on a gauze moistened with saline until needed. The palate is then sutured with chromic gut or silk to ensure hemostasis (Figure 6-15R). Most postoperative problems are the result of bleeding from the palate and not from the recipient site.

More recently, a microfibrillar collagen hemostat (MCH) has been used for donor site coverage to achieve hemostasis. The MCH is supplied in two forms: a shredded fluff (Avitene, C.R. Bard Inc., Murray Hill, New Jersey) and a non-woven web (Colostat, Kendal Co., Boston, Massachusetts). The shredded form is much more difficult to work with than the sponge form. Both prevent oozing from the exposed connective tissue of the palate (Saroff and colleagues, 1980; Stein and colleagues, 1985).

Graft Preparation. The underside or non-epithelial side of the graft is inspected for any glandular or fatty tissue remnants (Figure 6-15S). The thickness of the graft is also checked to ensure that it is generally smooth and uniform. If necessary, the graft, while on the moistened gauze, is trimmed of fat and glandular and excessive tissue using a new no. 15 scalpel blade (Figure 6-15T). Care should be taken not to overwork and perforate the graft.

The graft should now be brought to the patient's mouth and checked for the proper size and shape. The final shaping is usually done with scissors, outside the mouth and on a wet gauze.

Suturing is begun by holding the graft with Corn pliers and passing a suture through it (Figure 6-15V); whether silk or gut sutures are used does not matter. The graft is now returned to the mouth, where the suturing is continued. A Castroviejo needle holder facilitates suturing. It is also helpful to have the assistant hold the graft with a small round instrument as the first suture is being placed. This prevents the lifting and movement of the graft that is common on the first one or two sutures.

If a thick or full-thickness graft has been used, a horizontal stretching suture should be used to overcome the effects of primary contraction (Sullivan and Atkins, 1968a). This stretching suture allows the blood vessels within the graft to open, permitting early diffusion of fluids.

The final placement of the graft will be at the mucogingival junction (Figure 6-15W) if a submarginal incision was performed or on the denuded epithelial tissue (Figure 6-15X) if root coverage was attempted (for variations on this procedure, see Carvalho and colleagues, 1982; Holbrook and Ochsenbein, 1983).

The procedure is depicted clinically in Figures 6-17 to 21.

Common Reasons for Graft Failure

1. The most common cause of the failure of grafts is their use for root coverage. If the denuded root defect is small enough, the collateral circulation will be adequate to support bridging. On the other hand, when prominent roots with relatively wide areas of root exposure are grafted, two-point collateral circulation is insufficient for graft support. As a result, the center of the graft thins and becomes necrotic, and the graft splits and ultimately fails (Figure 6-22A).
2. Proper graft adaptation to the underlying periosteum is important. After suturing, slight pressure is applied to the graft with gauze moistened with saline for 5 minutes to permit fibrin clot formation and prevent bleeding. Bleeding will result in a hematoma under the graft, with subsequent necrosis (Figure 6-22B).
3. To permit adequate transfusion of the graft, it has been recommended that all fat and glandular tissue be removed prior to suturing to prevent possible necrosis and/or inadequate take (Figure 6-22C). Even though the need for this has been questioned, it is still a generally accepted procedure.
4. Graft movement as a result of inadequate or insufficient suturing will surely result in failure because no plasmatic diffusion will occur (Figure 6-22D).
5. The final failure is often seen only after the graft has healed. The clinical appearance is acceptable, but the graft is totally movable when probed. This is a failure of technique and results from not removing all loose connective tissue and muscle fibers from the periosteal bed prior to placement and not making sure that the bed is firmly attached to the underlying bone.

Recipient Modification

Graft stabilization and fixation are primary objectives of therapy. In an attempt to achieve more predictable stabilization, various modifications have been advocated.

Full-Thickness Recipient Site. The use of a full-thickness flap for placement of a graft directly onto bone has been advocated for achieving greater graft stability (Dordick and colleagues, 1976). It is advocated only where the alveolar housing is thick enough to prevent excessive bone resorption, with its resultant dehiscence and/or fenestration formation. Seibert (1980) recommended the use of a full-thickness flap only in the mandibular molar areas, where the periosteum is not firmly bound down and is easily lifted off the bone.

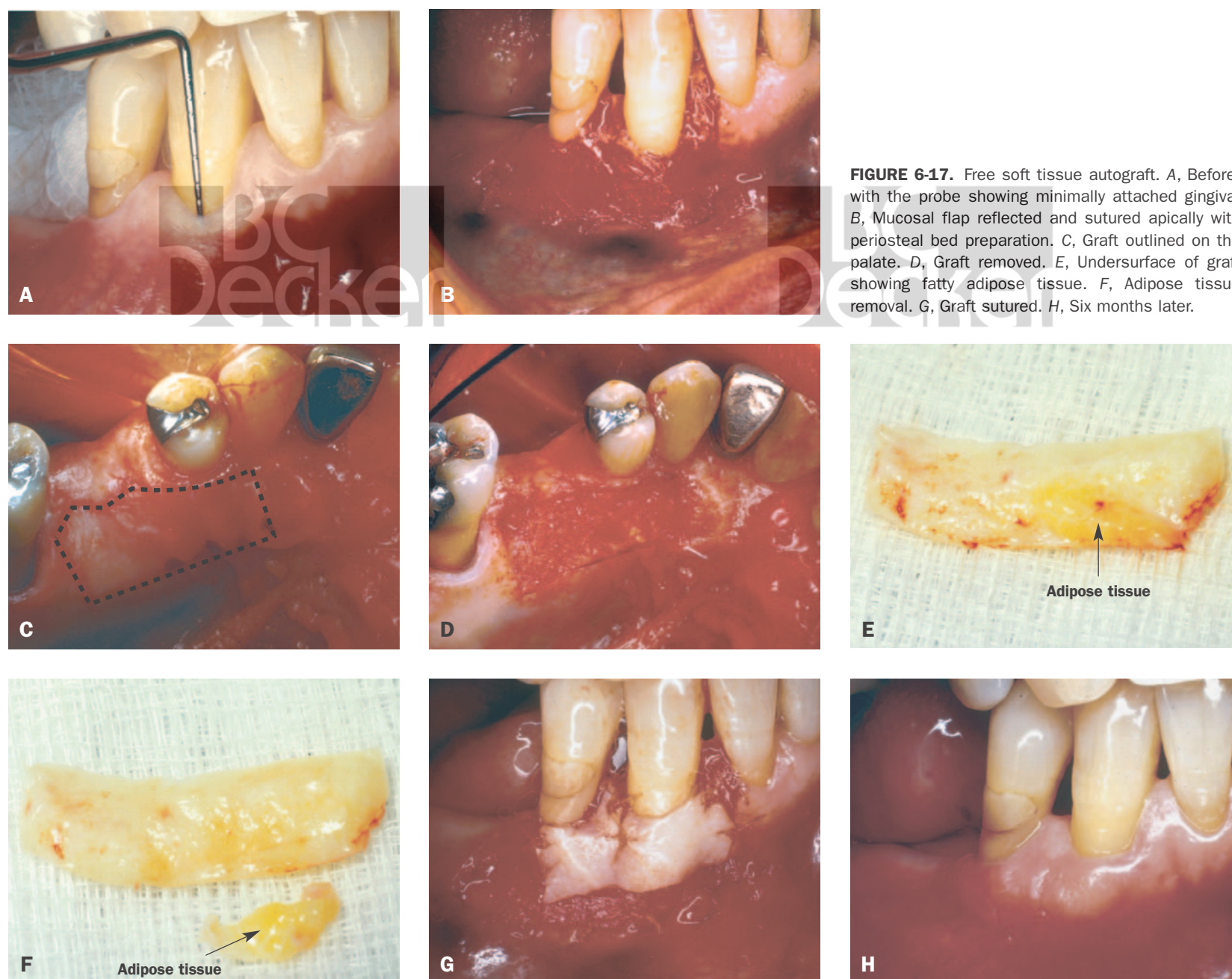


FIGURE 6-17. Free soft tissue autograft. A, Before, with the probe showing minimally attached gingiva. B, Mucosal flap reflected and sutured apically with periosteal bed preparation. C, Graft outlined on the palate. D, Graft removed. E, Undersurface of graft showing fatty adipose tissue. F, Adipose tissue removal. G, Graft sutured. H, Six months later.

The general consensus is that this technique need not be used if proper care is taken with the periosteal bed technique. Furthermore, healing is delayed with this technique, with a chance of necrosis or infection.

Procedure. A no. 15 scalpel blade is used to make an incision at the mucogingival junction down to the bone (Figure 6-23, A and B). The flap is reflected by blunt dissection and sutured apically, thus exposing the bone (Figure 6-23, C and D).

All other aspects of preparation of the donor area are the same (ie, epithelial denudation, removal of the remainder of alveolar mucosa). **Note:** This technique is not recommended for use when attempting root coverage. It is also not rec-

ommended when the periodontium is thin and the roots are palpable through the tissue.

Vertical Osseous Clefts. To overcome the negative aspects of total bone exposure, the technique has been modified further to permit preparation of the periosteal bed with vertical interradicular openings for bone exposure (Figure 6-24A). This has the main advantage of preventing excessive bone resorption over the radicular surfaces. The amount of additional retention achieved is questionable.

Periosteal Separation. In this procedure, periosteal fenestration (Robinson, 1961; Corn, 1962) is used at the base of the periosteal bed for

apical scarring and greater graft stabilization (Figure 6-24B). The separation is achieved using a no. 15 scalpel blade at the base to make a horizontal incision down to the bone. The incision is widened by blunt dissection, exposing 1 to 2 mm of bone. Apical suturing of the mucosal flap is optional.

This procedure achieves little additional graft stability when the donor site is prepared properly; also, it is limited in the mandibular premolar area because of the mental nerve. Morman and colleagues (1979) also pointed out that since the gingival blood supply is in an apico-occlusal direction and not a mesiodistal direction, this procedure may also compromise the blood supply.

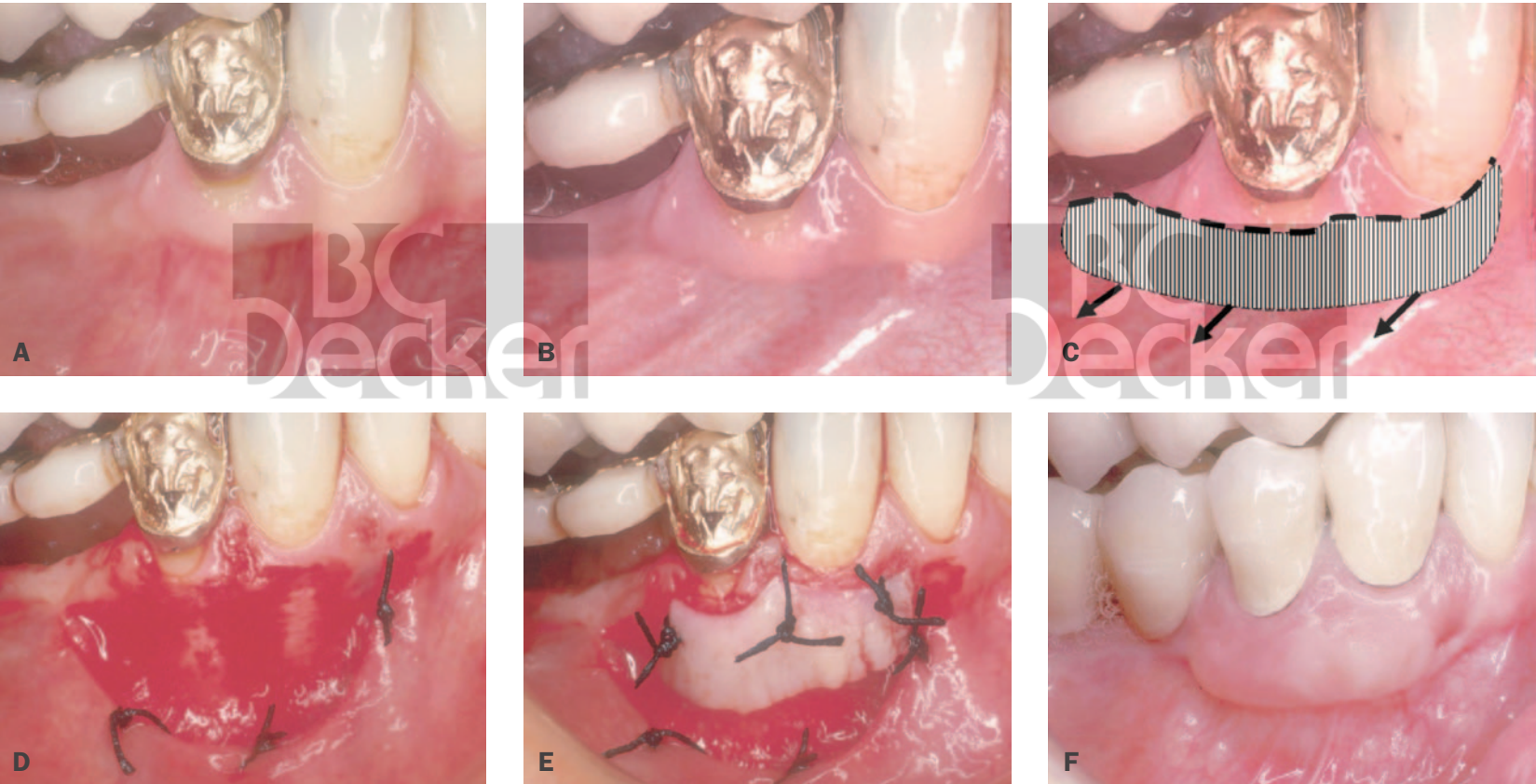


FIGURE 6-18. Free soft tissue autograft. A, Before; graft being done prior to prosthetics. B, Tension placed on tissue prior to the initial incision. C, Initial incision outlined at the point of tension of the mucosal tissue at the mucogingival junction. Tissue will immediately retract in the direction of the arrows. D, Mucosal flap is sutured apically with periosteal sutures. E, Graft sutured. F, Four years later. Prosthetics courtesy of Dr. William Irving, Needham, MA.



FIGURE 6-19. Free soft tissue autograft with cyanoacrylate. A, Before treatment. B, Periosteal bed prepared. C, Autograft positioned. D, Micropipet with cyanoacrylate. E, Graft stabilized with cyanoacrylate. F, Two months later.

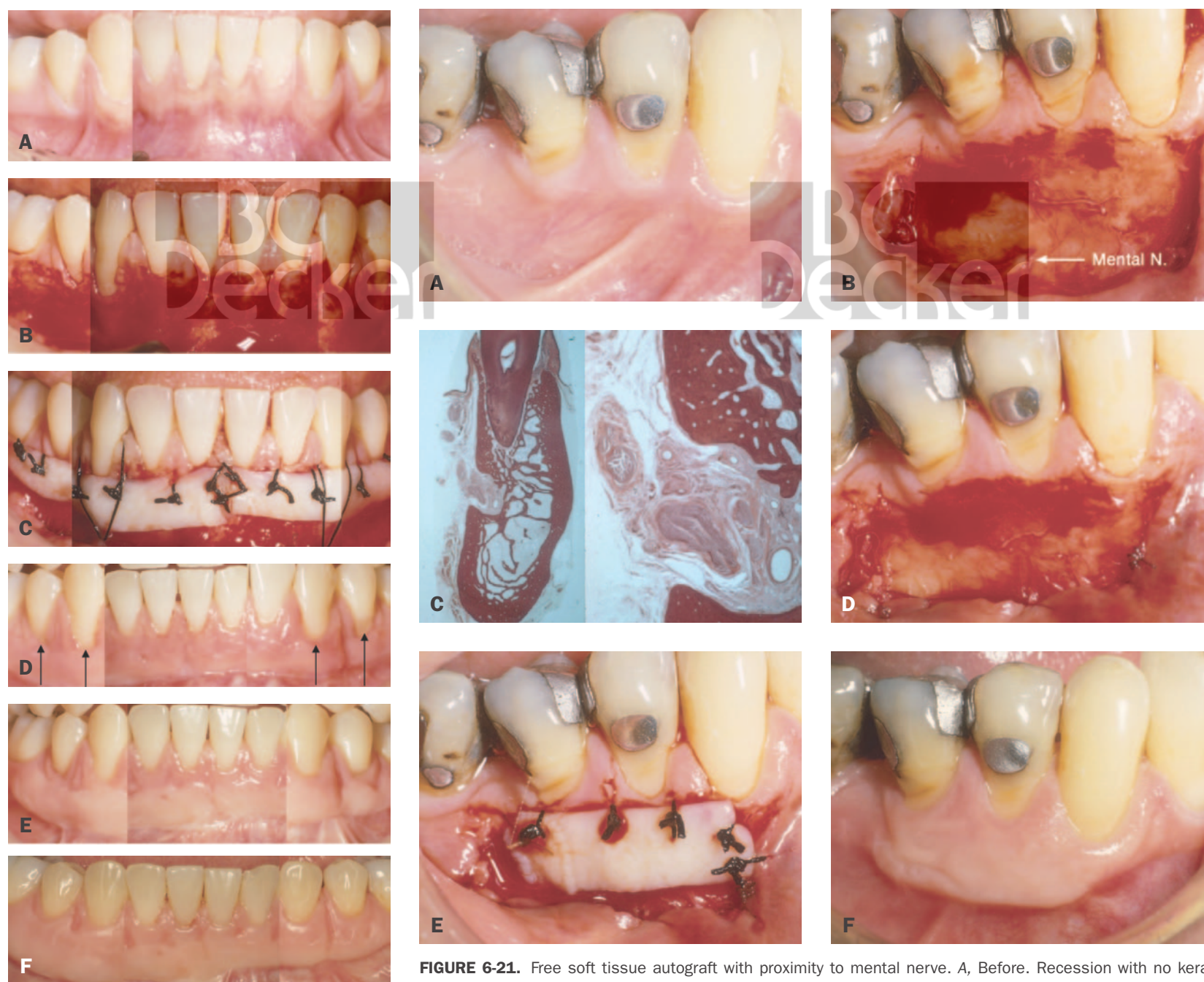


FIGURE 6-20. Free soft tissue graft. “Creeping attachment” composite. A, Before, composite view of lower. B, Periosteal bed prepared. C, Free gingival grafts placed below areas of recession. D, Six weeks later. Note areas of recession. E, One year later recession is corrected. F, Twelve years later with continued coronal tissue migration.

FIGURE 6-21. Free soft tissue autograft with proximity to mental nerve. A, Before. Recession with no keratinized gingiva. B, Mucosal flap reflected exposing mental N. C, Histology of mandibular canal and mental N (Courtesy of Dr. Irving Lickman). D, Mucosal flap sutured above mental N with 5-0 chromic sutures. E, Graft sutured. F, One year later.

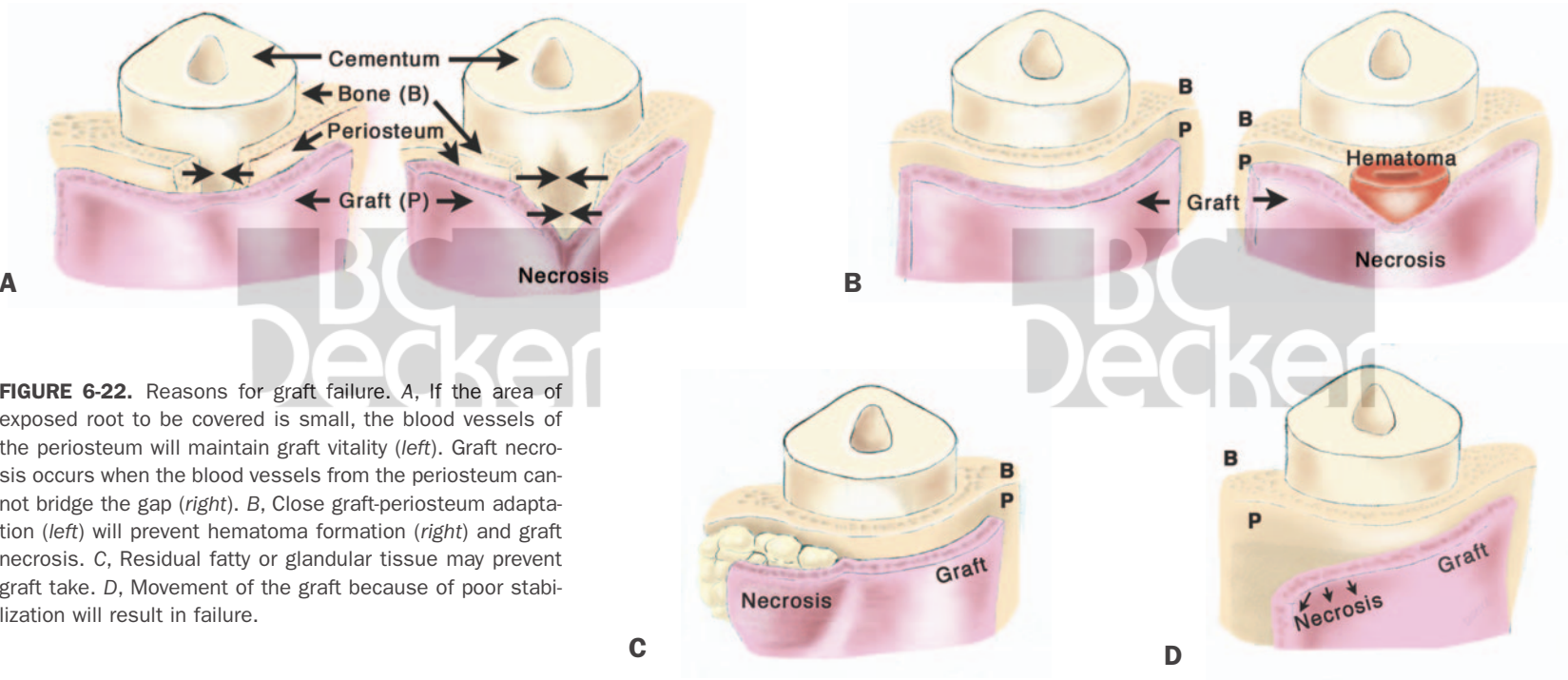


FIGURE 6-22. Reasons for graft failure. A, If the area of exposed root to be covered is small, the blood vessels of the periosteum will maintain graft vitality (*left*). Graft necrosis occurs when the blood vessels from the periosteum cannot bridge the gap (*right*). B, Close graft-periosteum adaptation (*left*) will prevent hematoma formation (*right*) and graft necrosis. C, Residual fatty or glandular tissue may prevent graft take. D, Movement of the graft because of poor stabilization will result in failure.

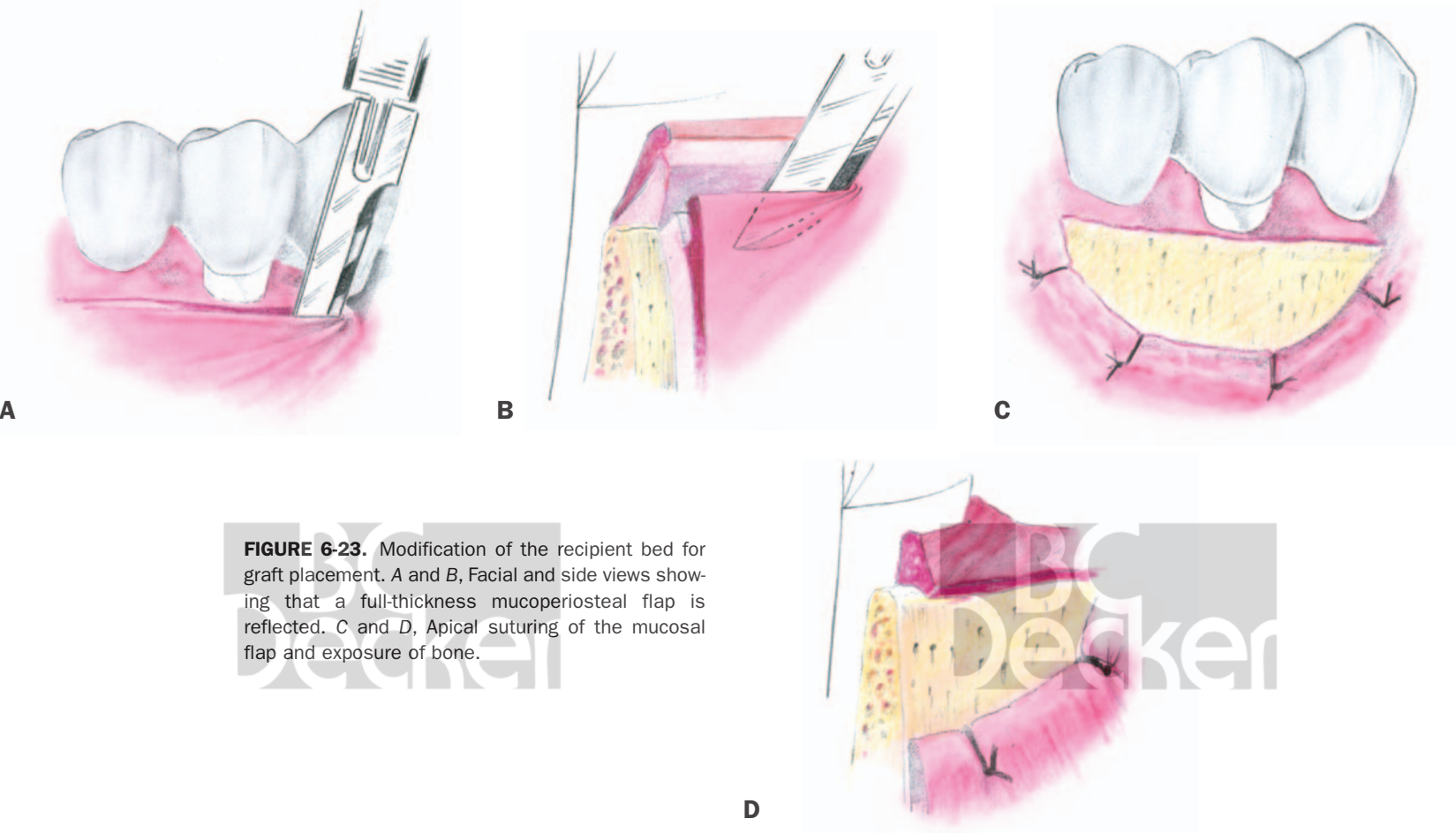


FIGURE 6-23. Modification of the recipient bed for graft placement. A and B, Facial and side views showing that a full-thickness mucoperiosteal flap is reflected. C and D, Apical suturing of the mucosal flap and exposure of bone.

Pedicle Flaps

Pedicle (laterally or coronally positioned) or papillary (single or double) flaps when combined with the connective tissue graft serve as the foundation of contemporary esthetic periodontal surgery (root coverage, ridge augmentation, prosthetic and implant esthetics). It is for this reason the technical skills for these basic procedures must be mastered.

Laterally Positioned Pedicle Flaps

Historical Review. In 1956, Grupe and Warren developed an original and unique procedure called the sliding flap operation for covering an isolated exposed root (Figure 6-25A). It involved moving a full-thickness flap to the mucogingival junction, after which a partial-thickness flap was raised. To prevent donor site recession, Grupe (1966) modified this to a submarginal incision on the donor site (Figure 6-25B). Staffileno (1964) solved this problem by using a partial-thickness flap to protect the donor site from recession. Corn (1964b) further modified this by adding a cutback incision to release tension (Figure 6-25C). He also took the pedicle from the edentulous ridge. Dahlberg (1969) used engineering principles with the rotated pedicle flap, which did not require a cutback incision (Figure 6-25D). Goldman and Smukler (1978) added the periosteally stimulated flap and a partial-full rotated flap in 1983, which allowed a full-thickness flap to cover the denuded root surface and a partial-thickness flap to cover the exposed bone (Figure 6-25E).

Advantages.

1. One surgical site
2. Good vascularity of the pedicle flap
3. Ability to cover a denuded root surface

Disadvantages.

1. Limited by the amount of adjacent keratinized attached gingiva
2. Possibility of recession at the donor site
3. Dehiscence or fenestrations at the donor site
4. Limited to one or two teeth with recession

Contraindications.

1. Presence of deep interproximal pockets
2. Excessive root prominences
3. Deep or extensive root abrasion or erosion
4. Significant loss of interproximal bone height

Basic Procedure. All pedicle flaps are variations on the basic procedural techniques outlined below.

Preparation of the Recipient Site. Figure 6-26A graphically shows one tooth with recession extending beyond the mucogingival junction and with no remaining attached gingiva. The basic incisions over the denuded root (a, b, c) and the anticipated flap outline (d, e, f) are depicted in Figure 6-26B.

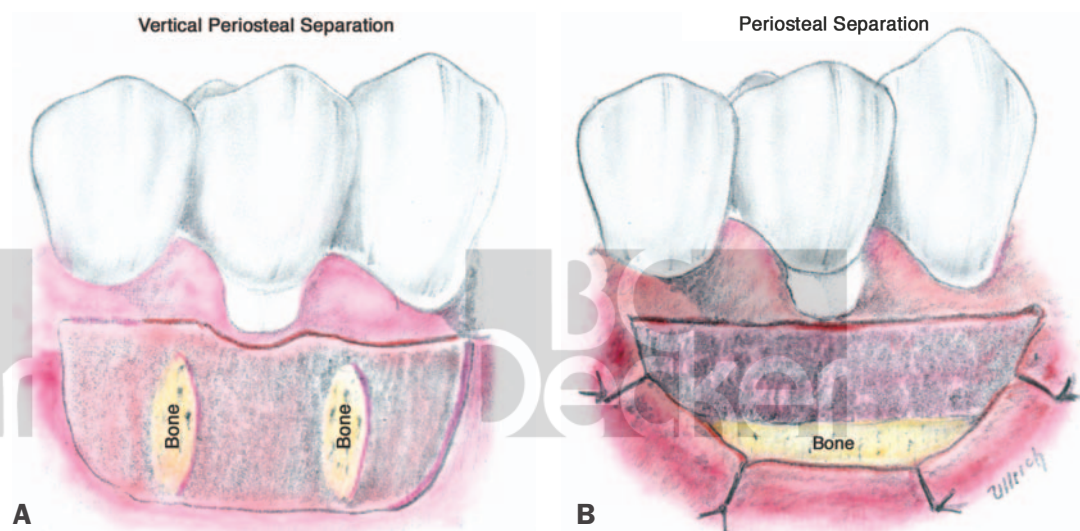


FIGURE 6-24. Modification of the recipient bed for graft placement. A, Vertical interradicular bone exposure to enhance graft take without exposure of bone over the radicular surfaces. B, Periosteal separation to bind down apical areas and prevent shrinkage or movement.

The first step prior to the start of surgery is root planing to remove softened cementum and to reduce or eliminate prominent convexity of the root. Citric acid (pH 1.0), tetracycline or EDTA (pH 7.0) is burnished in with a moistened cotton pledget for 3 to 5 minutes if root coverage is to be attempted. The citric acid is used to help detoxify the exposed root and expose the embedded connective tissue fibers. This exposure of tissue fibers may permit linkage (Stahl and Tarnow, 1985).

A no. 15 scalpel blade is used to make a V-shaped incision about the denuded root, removing the adjacent epithelium and connective tissue (Figure 6-26C). In the case of deep labial pockets and associated frenula, the apex of the V-shaped incision is extended far and wide enough apically to remove them (see Figure 6-26, C and D). It is also important that the V-shaped incision is beveled out on the opposite side from the donor area, permitting overlap and increased vascularity for the donor tissue in this area (see Figure 6-26D). Finally, all tissue remnants are removed from the area before the root is planed.

Preparation of the Donor Site. Figure 6-26B outlines the incision (d, e, f) that will be used for the donor flap. The donor flap as shown should be at least $1\frac{1}{2}$ times the size of the recipient area to be covered and 3 to 4 times longer than it is wide.

A partial-thickness flap is begun with a scalloped, inverse-beveled incision at the gingival crest using a no. 15 scalpel blade. The incision extends from the V-shaped incision to the vertical incision (Figure 6-26E). This incision is not made down to the bone. The horizontal incision is stopped at the mucogingival junction. All of the interproximal papillae are partially dissected, thinned, and maintained.

A vertical incision is now made with a no. 15 scalpel blade at the donor site, but it is not made

down to bone. It is extended far enough apically into the mucosal tissue to permit adequate mobility of the flap. The base of the flap must be wide, but not wider than the coronal portion, to permit adequate vascularity. The scalpel blade is inserted into the vertical incision apical to the mucogingival line (Figure 6-26F). The blade is moved in a coronal direction as tension is placed on the flap with tissue pliers, permitting easy separation. The flap is sharply dissected, making sure to carefully preserve all of the interproximal papillae.

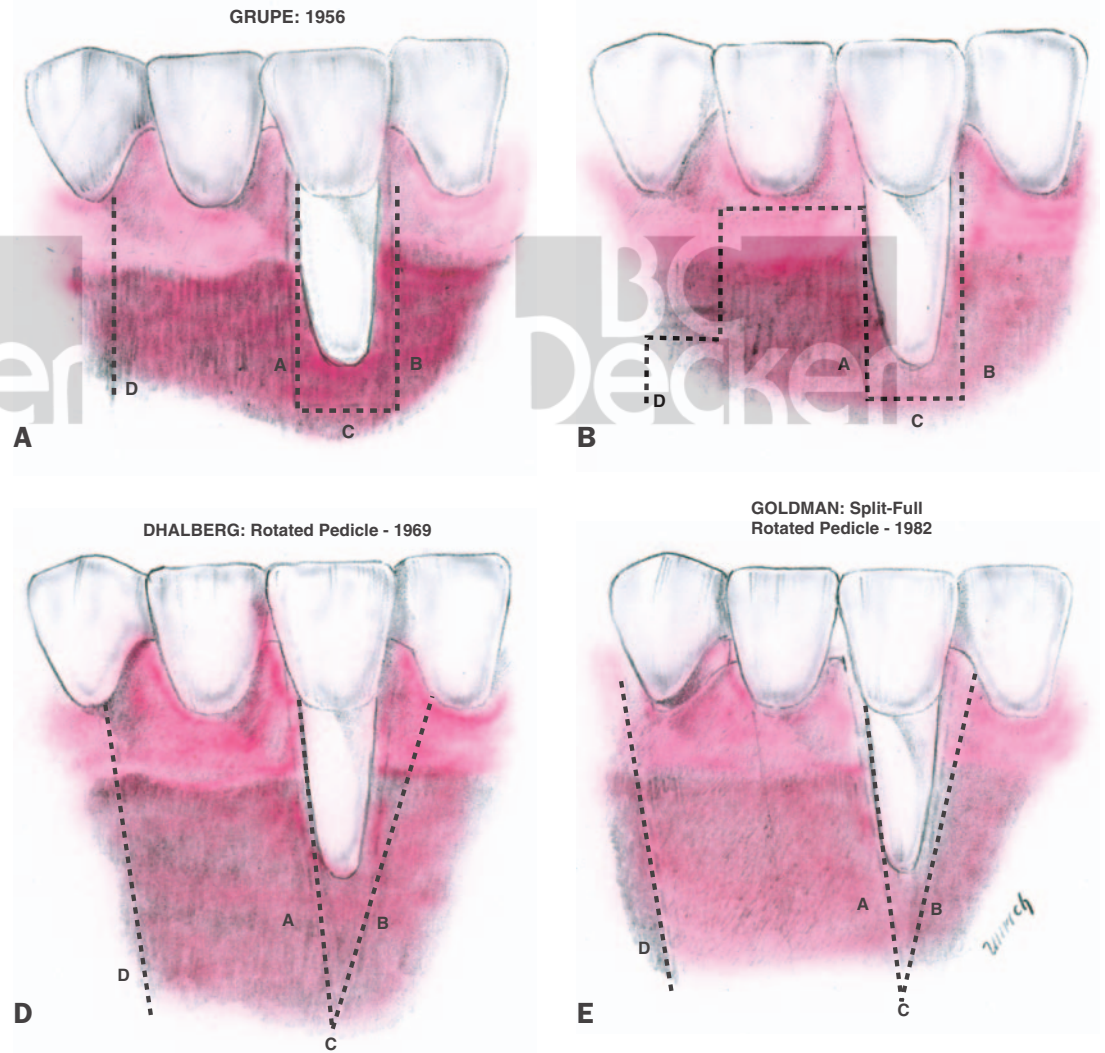
Preparation of Pedicle Flap. The flap is raised and reflected forward. A no. 15 scalpel blade is used to further free and smooth the underlying side from residual muscle and connective tissue fibers (Figure 6-26G). The flap should be free enough to permit movement to the recipient site, with no tension.

If a full-thickness pedicle flap were raised using blunt dissection, the flap would still have to be freed on its underlying side (Figure 6-26H). Note that, except for the use of the full-thickness flap, all other stages are similar.

When attempting to position the pedicle flap over the recipient site, if tension is encountered, a cutback or releasing incision will be required to dissipate the tension (Figure 6-26J).

In Figure 6-26, K and L show the finished case. The pedicle flap is positioned coronally 1 to 2 mm onto the enamel of the recipient tooth or to the maximum height that the interproximal tissue will allow. The concept that the maximum height for gaining coverage is determined by the interproximal tissue height has sometimes been termed the peak theory. Suturing is done with 4-0, 5-0, or 6-0 silk or gut suture. All sutures are interrupted except for a sling suture, which is used to pull the papillae interproximally and hold the tissue tightly against the neck of the tooth. It

FIGURE 6-25. Historical outline of the laterally positioned flap design. *A*, Original Grupe design. *B*, Sub-marginal incision placement to prevent recession at the donor site. *C*, Cutback or releasing incision for tension release. *D*, Rotated pedicle flap permitting placement without the need for a cutback incision. *E*, Use of more than one tooth to permit periosteal placement over exposed root with bone exposure (stimulated or nonstimulated).



is sometimes helpful to hold the pedicle with Corn suture pliers for the first one or two sutures or until the flap is stabilized adequately.

Note that the only exposed areas are the interradicular spaces between the teeth and not the facial surfaces. This helps prevent recession at the donor site and in a full-thickness pedicle flap will prevent excessive bone resorption. Further, note the overlap of the pedicle with the beveled-out portion of the V-shaped incision.

The procedure is depicted clinically in Figures 6-27 to 30.

Common Reasons for Failure.

1. Figure 6-31A represents one of the more common errors of tension at the base of the distal incision. This is easily corrected by use of a releasing or cutback incision.
2. Figure 6-31B represents the worst type of mistake, a pedicle that is too narrow. There is no correction for this, and failure is almost ensured. The basic rule is for a pedicle or donor flap to be at least $1\frac{1}{2}$ times as wide as the recipient bed.
3. Figure 6-31C is a common fault of the full-thickness flap that results in exposure of bone

over the radicular surface. This permits bone loss, fenestration, and/or dehiscence formation. The right side of Figure 6-31D is representative of the type of bony defects found on the radicular surface of a thin periodontium. Full-thickness flaps are contraindicated in the presence of a thin periosteum.

4. Figure 6-31E depicts poor stabilization and mobility of the flap. Movement prevents intimate contact between the tooth and the flap and generally results in failure.

Edentulous Ridge Modification. This procedure is similar to that for laterally positioned pedicle flaps in all respects except that if the edentulous area is long enough, more teeth may be treated and the amount of keratinized donor tissue may be increased by operating more lingually or palatally to the ridge.

Figure 6-32A shows a molar with recession on the mesiobuccal root adjacent to an edentulous area.

Figure 6-32B shows the basic outline of the incisions and a probe extending beyond the mucogingival junction. In making the V-shaped incision (a, b, c), the surgeon takes care not to

involve the furcation area and extends the incision down far enough apically to remove any pockets. Instead of a straight vertical incision, more of an oblique incision is made in the donor area. This permits more of a rotated pedicle flap and creates minimal need for a cutback or releasing incision.

In Figure 6-32C, a no. 15 scalpel blade has been used to make a V-shaped incision and remove a wedge. The initial incision is carried along the crest of the ridge as a partial-thickness incision (Figure 6-32D). A full-thickness pedicle flap is often used over the edentulous area because of the regenerative ability of the bone and the lack of adjacent teeth.

In Figure 6-32, E and F represent situations in which the zone of keratinized gingiva is adequate in one (see Figure 6-32E) and inadequate on the other (see Figure 6-32F). In the case of the inadequate zone, the incision will have to be made on the lingual (palatal) aspect of the ridge to increase the amount of keratinized tissue. The dotted lines in both represent the partial-thickness incision.

The pedicle is dissected with a no. 15 scalpel blade being moved in an apico-occlusal direction



FIGURE 6-26. Laterally positioned pedicle flap. *A*, Preoperative view of a root exposed as a result of recession and lack of attached gingiva. *B*, Basic incisions are outlined. *C*, A V-shaped incision is made about the exposed root. *D*, The V-shaped incision is removed. Note that the beveled incision on the opposite side of the donor is to permit overlap of the flap. *E*, Coronal portion of the pedicle flap begun. *F*, Final dissection of the pedicle is in an apico-occlusal direction. *G*, The pedicle flap is released and reflected, exposing underlying periosteum (P). *H*, If a full-thickness pedicle flap were raised, the underlying bone (B) would have been exposed. *I*, Tension is placed on the pedicle when positioning is attempted. *J*, The cutback or releasing incision is now made (E–F). *K*, The partial-thickness pedicle is sutured with periosteum covering bone. *L*, Example of the full-thickness pedicle flap with bone exposure.

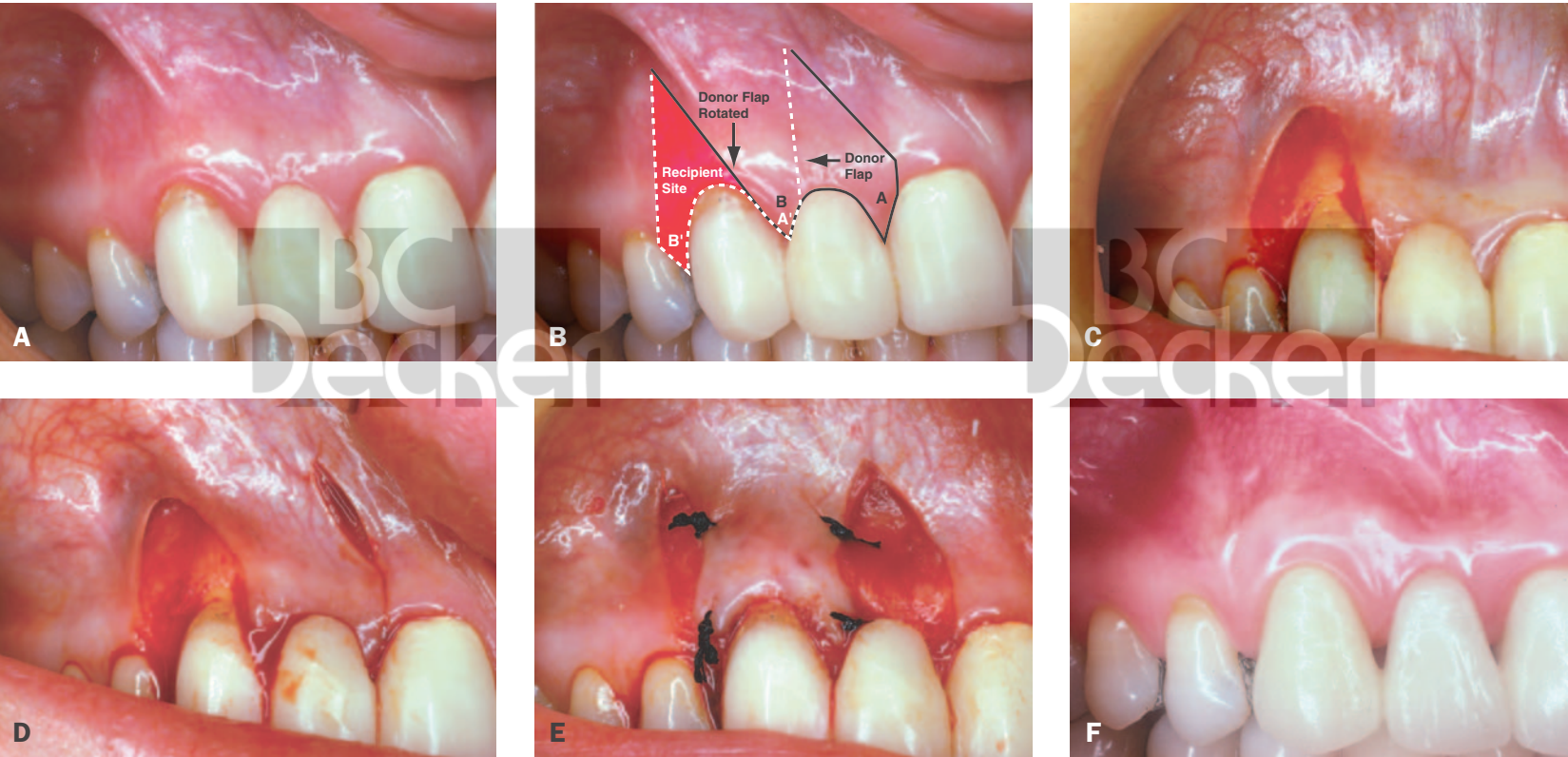


FIGURE 6-27. Partial-thickness laterally positioned flap. *A*, Before treatment. Probe in place, showing no attached gingiva. *B*, Incisions outlined: V-shaped incision and pedicle flap, which will be moved distally. The pedicle flap will be rotated to the recipient site so that A→A' and B→B' (see Figure 6-5). *C*, V-shaped incision completed and wedge removed. Note the beveled-out portion of the incision, permitting adequate overlap. *D*, Pedicle flap incisions completed. Note angulation of the incisions toward the recipient site. *E*, Pedicle flap sutured. Note total lack of tension. *F*, Two years later. Note the significant increase in attached gingiva. Prosthetics courtesy of Dr. William Irving, Needham, MA.



FIGURE 6-28. Laterally positioned submarginal pedicle flap. *A* and *A'*, Preoperative clinical views showing recession. *B* and *B'*, Pedicle flaps rotated, partial thickness (*B*) and Full thickness (*B'*) over the buccal surface. *C* and *C'*, Final result one year later showing complete coverage.

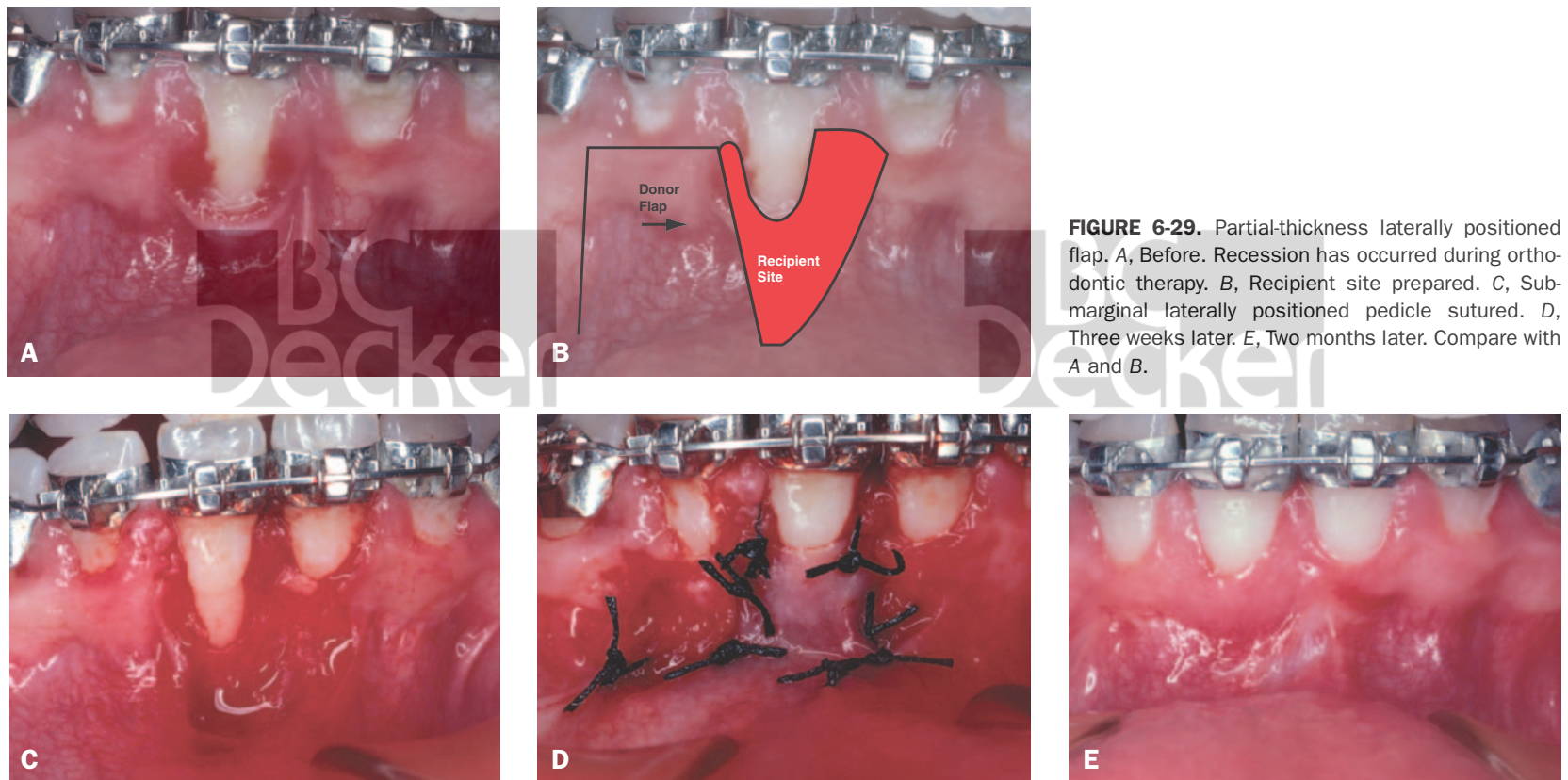
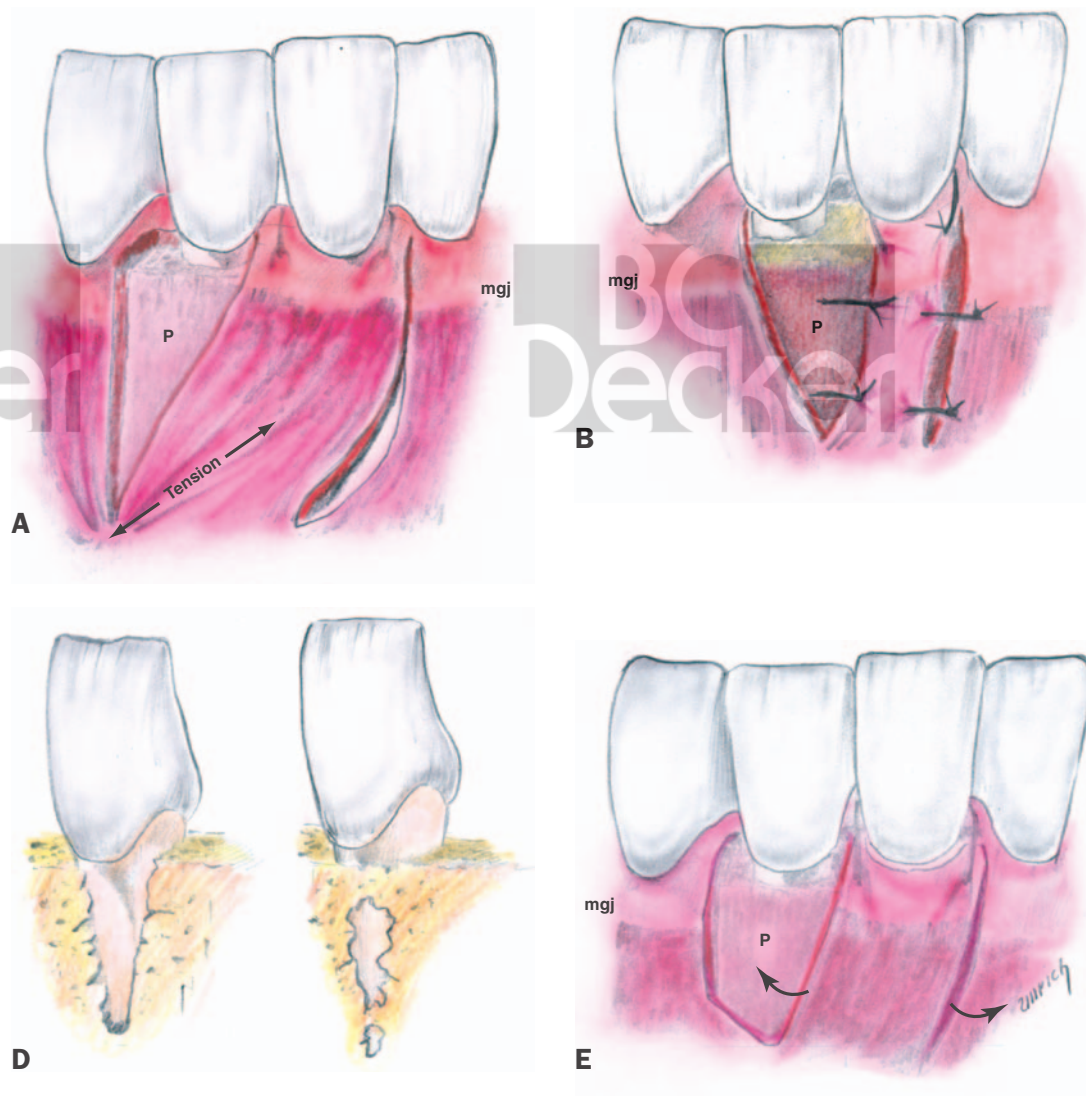


FIGURE 6-29. Partial-thickness laterally positioned flap. A, Before. Recession has occurred during orthodontic therapy. B, Recipient site prepared. C, Submarginal laterally positioned pedicle sutured. D, Three weeks later. E, Two months later. Compare with A and B.



FIGURE 6-30. Double lateral submarginal sliding flap. A, Initial view with recession on teeth #24 and 25. Note wide zones of keratinized gingiva on teeth #23 and 26. B, Diagrammatic view of incision outline. Submarginal donor incisions will prevent recession at these sites. C, Flaps positioned and sutured. D, Final result with excellent gingival health, wide zones of keratinized gingiva and almost complete root coverage.

FIGURE 6-31. Reasons for pedicle flap failure. A, Inadequate stabilization because of tension. B, The pedicle flap is too narrow. C, Bone exposed, resulting in dehiscence or fenestration formation. D, Excessive movement because of poor stabilization.



(Figure 6-32G). Once split, it is reflected forward and freed from underneath using the same scalpel blade (Figure 6-32H).

In Figure 6-32I, the flap is reflected and the beveled-out incision is added to the fixed recipient portion of the V-shaped incision to permit overlapping of the donor pedicle. Figure 6-32J shows a full-thickness pedicle flap.

In Figure 6-32, K and L show the sutured pedicle in place. Note that when the oblique incision at the donor area is properly executed, no cutback incision is required.

The procedure is depicted clinically in Figures 6-33 to 35.

Oblique Rotated Pedicle Flap. Dahlberg (1969) designed incisions for pedicle flaps based on a center of rotation about an axis at the base of the vertical donor incision. This permitted the pedicle to be moved over the donor site without tension and without the need for releasing incisions.

Figure 6-36A shows the outline of the incisions. The donor flap is outlined by two incisions, one of which also forms part of the V-shaped incision. Each incision is made at an oblique angle. The

two vertical incisions are carried apically far enough that the apex of the V-shaped incision extends distal to the recipient site, and the base of the donor incision extends to the distal line angle of the next tooth.

The incisions, V-shaped and oblique, are made with a no. 15 scalpel blade, and the flap is dissected as described earlier (Figure 6-36B). The pedicle is then rotated over the recipient site with no tension and is sutured in place (Figure 6-36C).

Periosteally Stimulated Pedicle Flap. To enhance the chance of root coverage, Goldman and Smukler (1978) thought of using a stimulated periosteum, one of which was in an activated state.

As shown in Figure 6-37A, a sharp instrument or 25-gauge needle is used to make sharp penetrations through the gingivae that firmly engage the underlying bone. This is carried out under anesthesia 17 to 21 days prior to surgery to slightly damage the periosteum and induce healing. The theory is that healing activates primordial cells capable of bone and cementum formation.

Figure 6-37B shows the lifting of a full-thickness pedicle flap 17 to 21 days later. The flap

is placed over the recipient site and sutured (Figure 6-37C).

Partial-Full-Thickness Pedicle Flap. In an effort further to enhance root coverage, Goldman and colleagues (1982) introduced a technique that had the advantage of allowing placement of a full-thickness flap over the denuded root surface and at the same time permitting coverage of the exposed donor site with periosteum.

In Figure 6-38, A and B show the area of recession and the outline and removal of the V-shape incision using a no. 15 scalpel blade.

The variation in technique comes in the next step. The pedicle flap is begun at least two teeth away from the recipient site (Figure 6-38C). A partial-thickness flap is used over the tooth farthest away. This part of the procedure is similar to that already outlined.

When approaching the approximating tooth, the no. 15 scalpel is directed toward the bone and in an apico-occlusal direction, cutting into the periosteum. This allows a full-thickness flap to be raised by blunt dissection with a sharp periosteal elevator (Figure 6-38D).

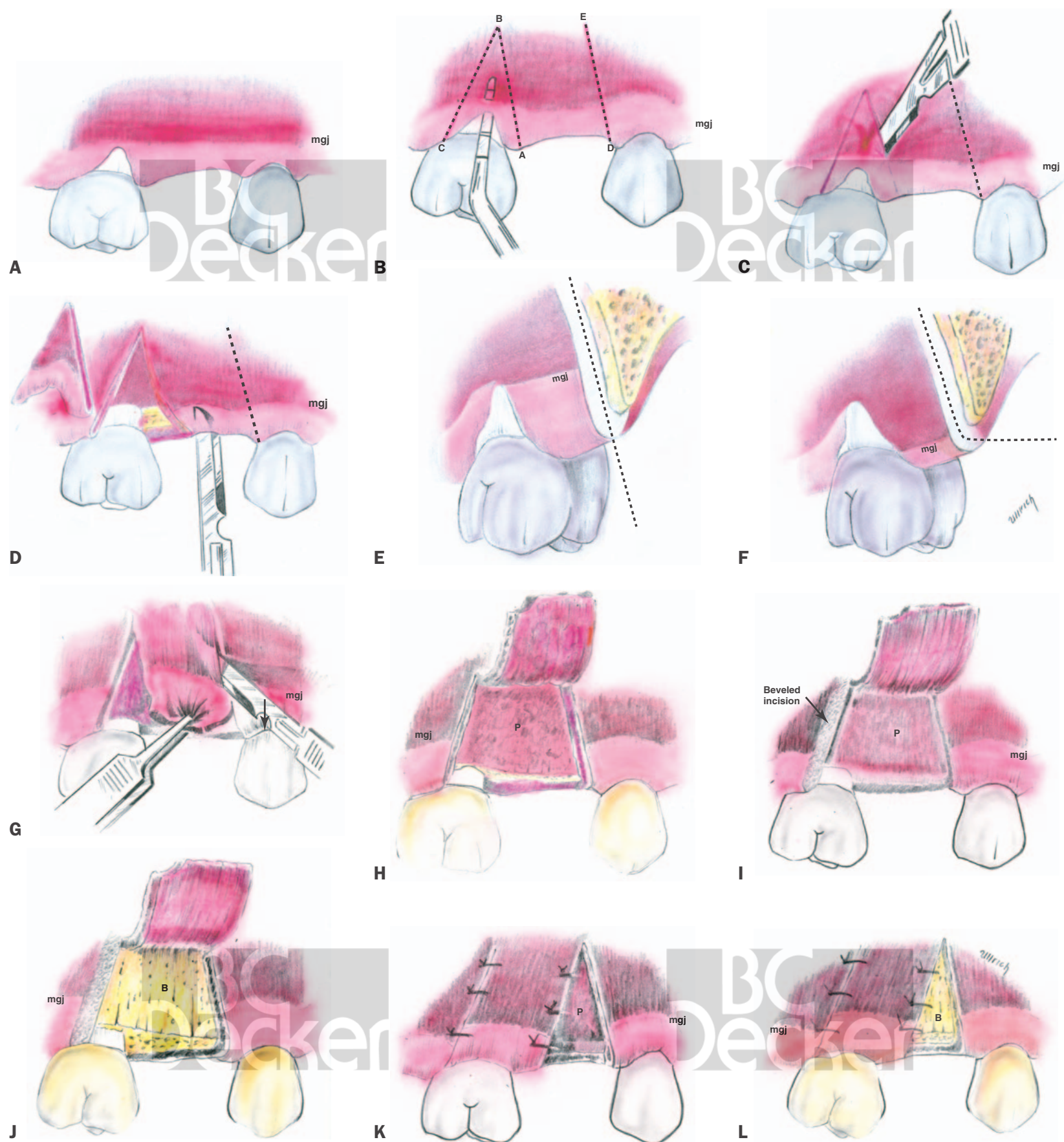


FIGURE 6-32. Laterally positioned rotated pedicle flap from the edentulous ridge. *A*, Preoperative view of a molar with recession and no attached keratinized gingiva. *B*, Outline of incisions: a to c is the V-shaped incision; d to e is the oblique, flap-releasing incision. The probe shows a lack of attached gingiva. *C*, The V-shaped incision is begun. *D*, With the removal of the V-shaped incision, a partial-thickness pedicle flap is raised. *E* and *F*, Dotted lines outline the incision for the pedicle flap in the presence of adequate (*E*) or inadequate (*F*) zones of keratinized gingiva. *G*, Dissection on the partial-thickness pedicle flap is completed in an apico-occlusal direction. *H*, Flap reflected. *I*, A bevel is placed on the distal side of the V-shaped incision to permit flap overlap. *J*, A full-thickness pedicle flap. *K* and *L*, Sutured flaps of partial- and full-thickness designs, respectively. B = bone; P = periosteum.

FIGURE 6-33. Partial-thickness laterally positioned flap from the edentulous ridge. A, Before treatment. Note lack of attached gingiva. B, Partial-thickness rotated pedicle flap outlined and V-shaped incision removed. C, Pedicle flap sutured over the mesiobuccal root. D, Eight months later. Note the increase in attached gingiva. E, Probe showing minimal sulcus depth over the mesiobuccal root. Compare with A. Originally contributed by Edward S. Cohen, DMD, to *Glickman's Clinical Periodontology* and reproduced with the permission of W.B. Saunders Co.

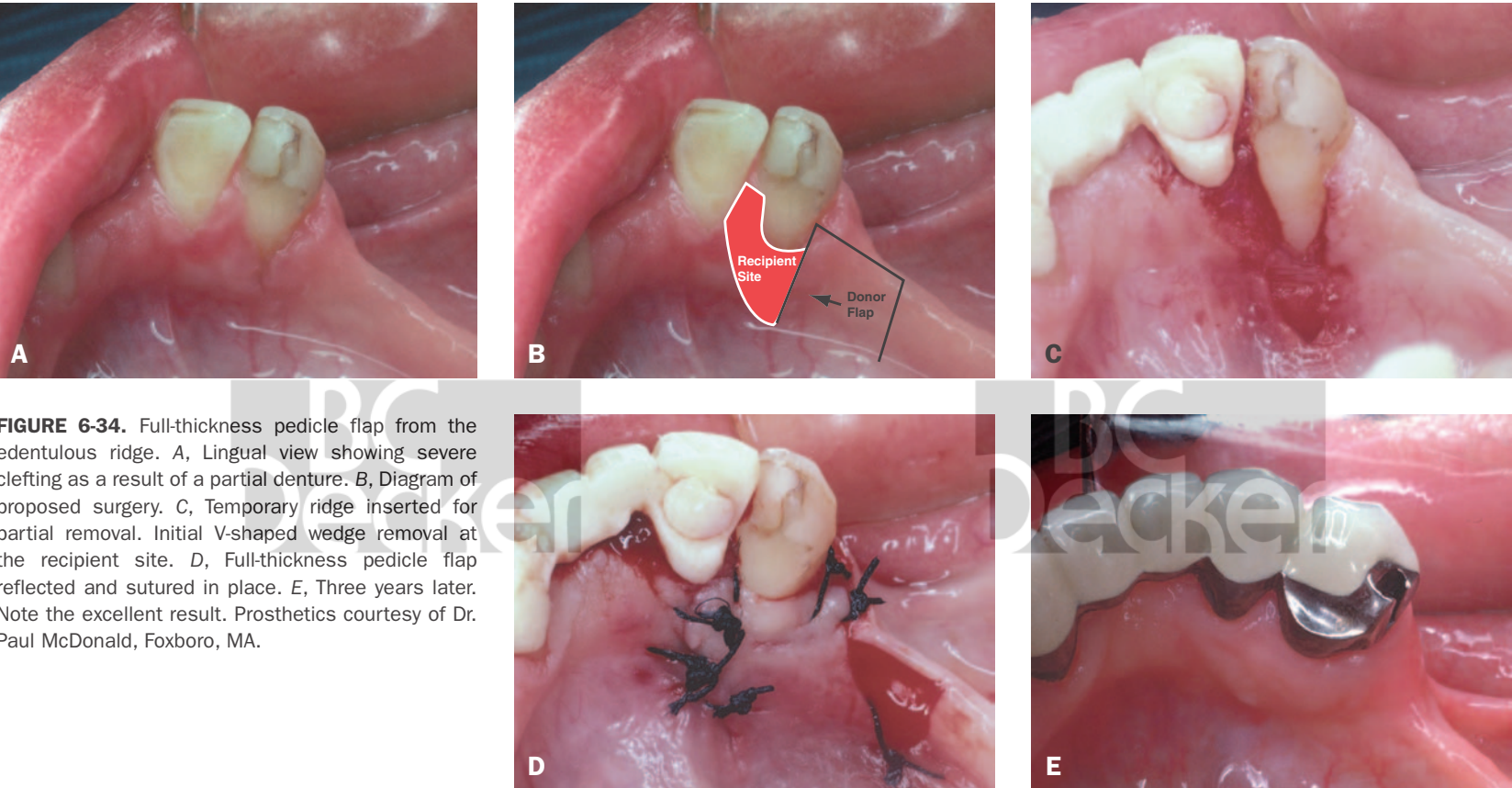


FIGURE 6-34. Full-thickness pedicle flap from the edentulous ridge. A, Lingual view showing severe clefting as a result of a partial denture. B, Diagram of proposed surgery. C, Temporary ridge inserted for partial removal. Initial V-shaped wedge removal at the recipient site. D, Full-thickness pedicle flap reflected and sutured in place. E, Three years later. Note the excellent result. Prosthetics courtesy of Dr. Paul McDonald, Foxboro, MA.

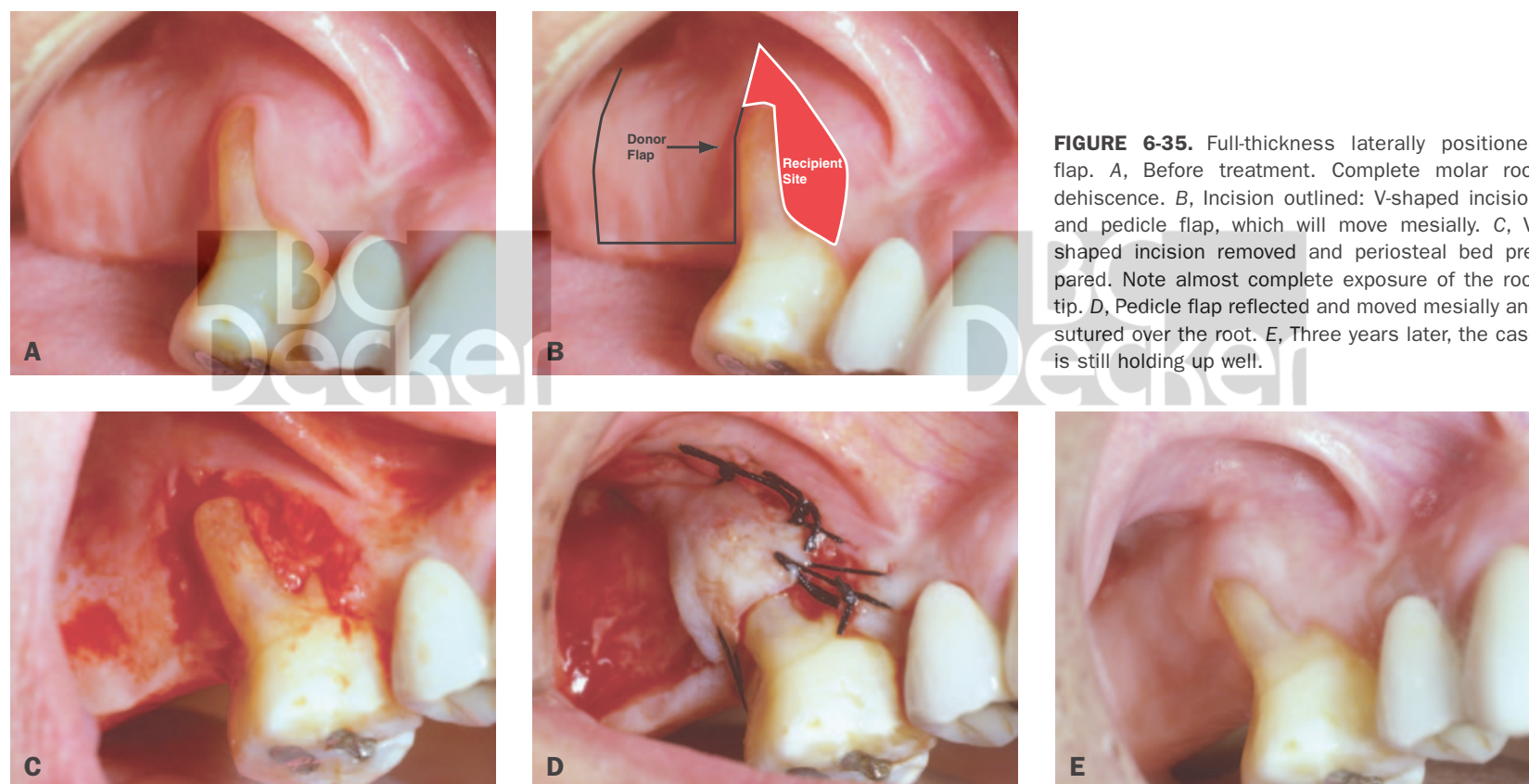


FIGURE 6-35. Full-thickness laterally positioned flap. A, Before treatment. Complete molar root dehiscence. B, Incision outlined: V-shaped incision and pedicle flap, which will move mesially. C, V-shaped incision removed and periosteal bed prepared. Note almost complete exposure of the root tip. D, Pedicle flap reflected and moved mesially and sutured over the root. E, Three years later, the case is still holding up well.

Figure 6-38E shows the flap reflected to illustrate the partial-full-thickness design. Note the beveled-out area of the V-shaped incision.

In Figure 6-38F, the flap is sutured in place, and only the periosteally covered area is left exposed.

The clinical procedure is shown in Figure 6-39.

Submarginal Incisions. This type of incision can be used for all procedures provided that an adequate width (25 mm) of keratinized gingiva is present at the donor site. This will permit leaving a small collar of tissue about the neck of the teeth to prevent recession at the donor site, thus facilitating use of a full-thickness pedicle flap if desired. In Figure 6-40A, the basic problem is outlined. In Figure 6-40B, the flap has been raised (in this case, a partial-full-thickness pedicle) and the V-shaped incision has been removed. The flap is rotated over the recipient site and sutured below the submarginal incision (Figure 6-40C).

The procedure is depicted clinically in Figures 6-41 and 6-42.

Double-Papillae Laterally Positioned Flaps

This procedure, first described by Wainberg as the double lateral repositioned flap (see Goldman and colleagues, 1964), was refined by Cohen and Ross (1968) as the double-papillae flap. It is designed to achieve an adequate zone of attached

keratinized gingiva and/or coverage of a denuded root surface by joining two interdental papillae.

Indications.

1. When the interproximal papillae adjacent to the mucogingival problem are sufficiently wide
2. When the attached keratinized gingiva on an approximating tooth is insufficient to allow for a laterally positioned flap
3. When periodontal pockets are not present

Advantages.

1. The risk of loss of alveolar bone is minimized because the interdental bone is more resistant to loss than is radicular bone.
2. The papillae usually supply a greater width of attached gingiva than can be gotten from the radicular surface of a tooth.
3. The clinical predictability of this procedure is fairly good.

Disadvantage.

1. The primary disadvantage of this procedure is in having to join together two small flaps in such a way that they act as a single flap.

Procedure. The mucogingival junction is the line of demarcation between the coronally attached gingiva and the oral mucosa below (Figure 6-43A). When the periodontal probe is inserted, note that it extends 1 mm beyond the mucogingival line (Figure 6-43B); therefore, that 1 mm of marginal tissue is not attached to the root surface.

The surgical incisions are outlined in Figure 6-43B by dotted lines. The lateral releasing incisions will be made at the mesiofacial and distofacial line angles of the adjacent teeth and should not encroach on the radicular surfaces of the approximating teeth because this will expose radicular bone. A V-shaped incision will be made to remove a wedge of gingiva over the root.

This incision should extend far enough apically into the mucosa to prevent bunching of the tissue when the flaps are brought together. Horizontal incisions will be made across the tops of the papillae to allow better placement of the flap.

Using a no. 15 scalpel blade, the V-shaped incision is made and extended to the depth of, but not including, the periosteum (Figure 6-43C). The V-section is then removed, and the root surface is thoroughly scaled (Figure 6-43D). Note that the periosteum has been retained.

Once the horizontal incisions are made across the tops of the papillae (Figure 6-43E), the tissue is grasped with rat-tail tissue pliers and gently lifted as it is separated from the underlying tissue by means of a no. 15 scalpel. Care must be exercised to prevent lifting the periosteum off the bone or accidentally puncturing or severing the flap.

The tissue at the mucogingival line is more firmly bound and is easier to separate from the mucosal side. Therefore, to completely release the flap, the scalpel blade is inserted into the base of the lateral releasing incision and moved in an apico-occlusal direction (Figure 6-43F) until the



A **B** **C**

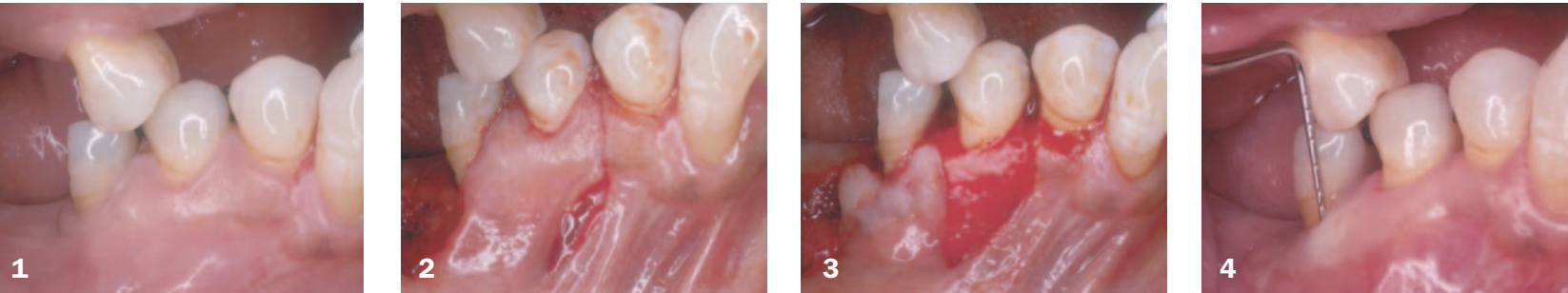
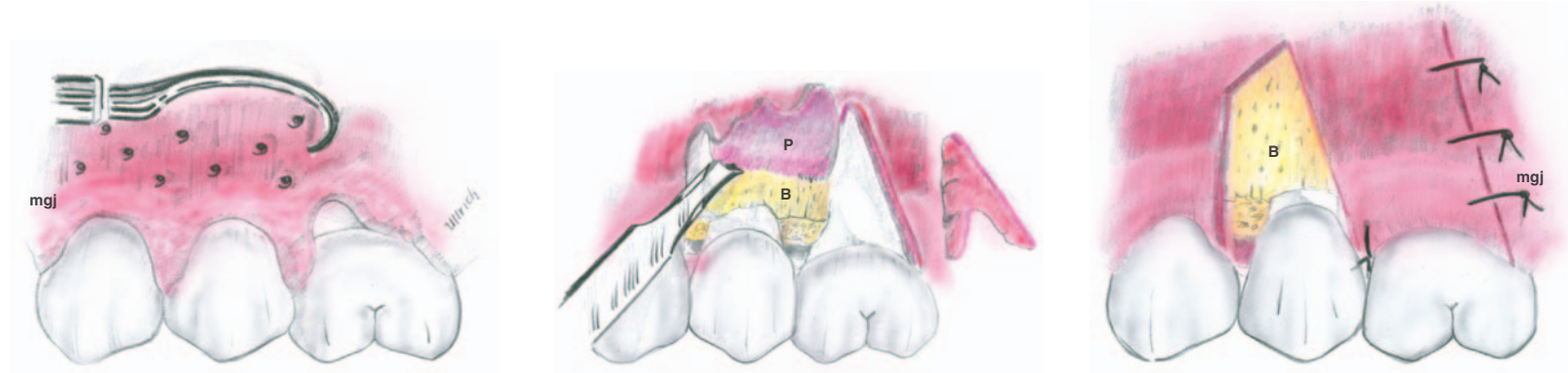


FIGURE 6-36. Oblique rotated pedicle flap. Diagrammatic view: *A*, V-shaped incision and pedicle flap outlined. *B*, Incisions completed and V-shaped incision removed. Note the obliquely angled donor flap. *C*, Pedicle flap rotated over the tooth. Clinical view: 1, Preoperative clinical view with the probe in place. Pockets extend beyond the mucogingival line. 2, Incisions outlined. 3, Pedicle flap rotated. Note complete lack of tension. 4, Seven months later. Note the increase in attached gingiva.



A **B** **C**

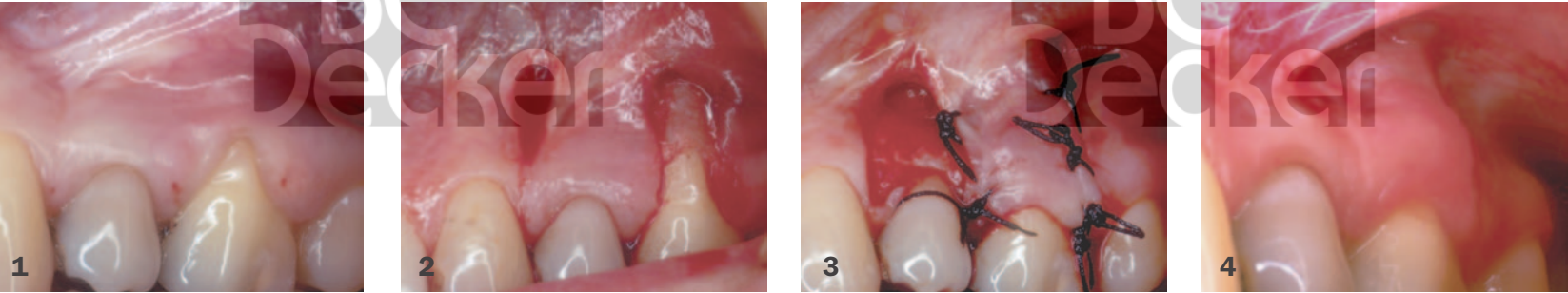


FIGURE 6-37. Periosteally stimulated pedicle flap. Diagrammatic view: *A*, Periosteal stimulation 17 to 21 days prior to surgery. *B*, Full-thickness pedicle flap raised and bone (B) exposed. *C*, Pedicle flap sutured in position with bone (B) exposed on the recipient site. Clinical view: 1, Before surgery, 21 days after stimulation. 2, Incisions completed and V-shaped incision removed. 3, Full-thickness flap reflected and sutured over the recipient site. 4, Six months later, total root coverage with minimal recession at the donor site.

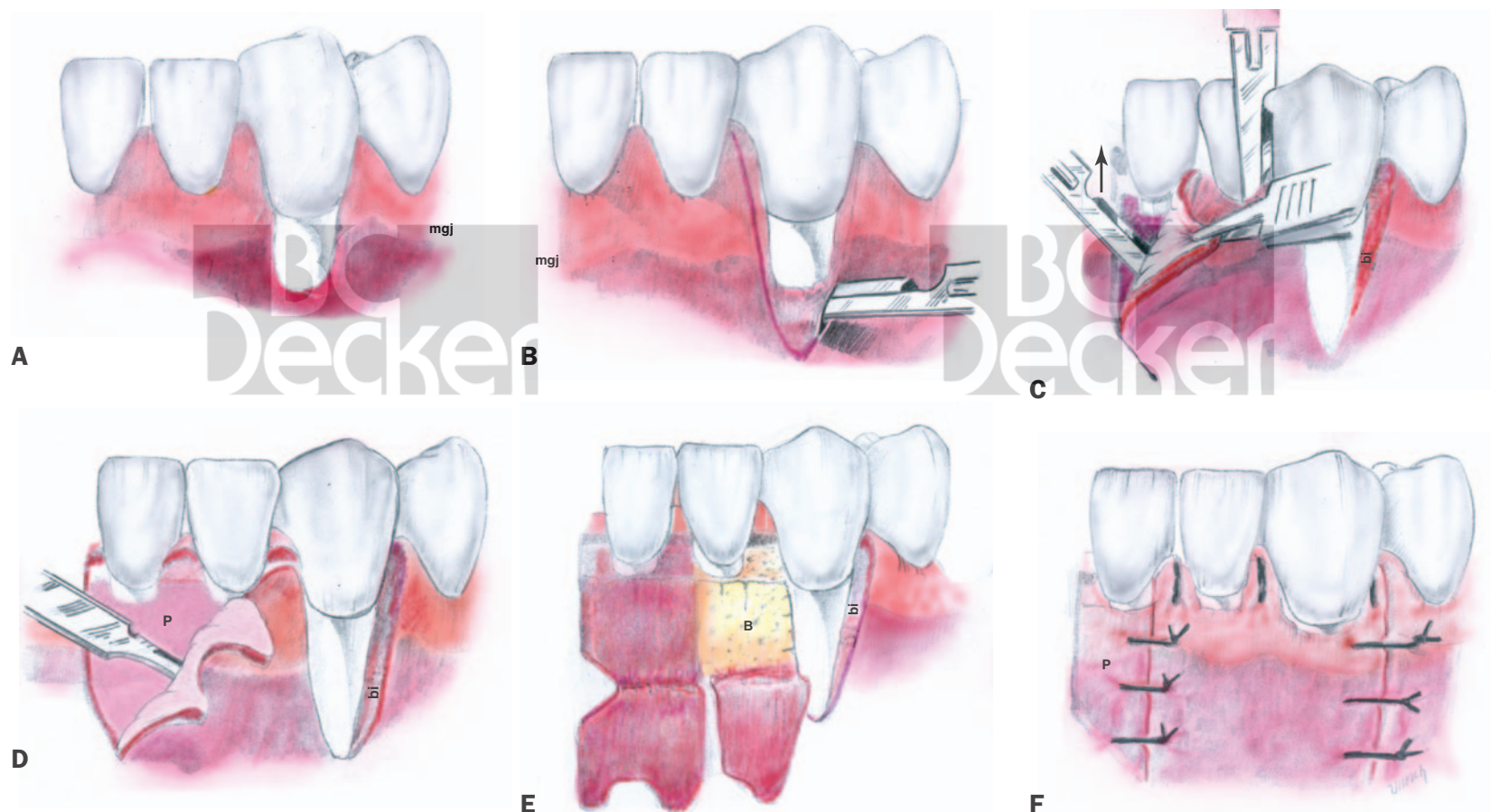


FIGURE 6-38. Partial-full-thickness pedicle flap. A, Initial view. B, V-shaped incision over the exposed root begun. C, V-shaped beveled incision (bi) completed and partial-thickness flap begun. D, Partial-thickness flap portion completed and full-thickness flap begun. B = bone; P = periosteum. E, Partial-full-thickness flap raised. F, Flap sutured with overlap of the beveled incision.

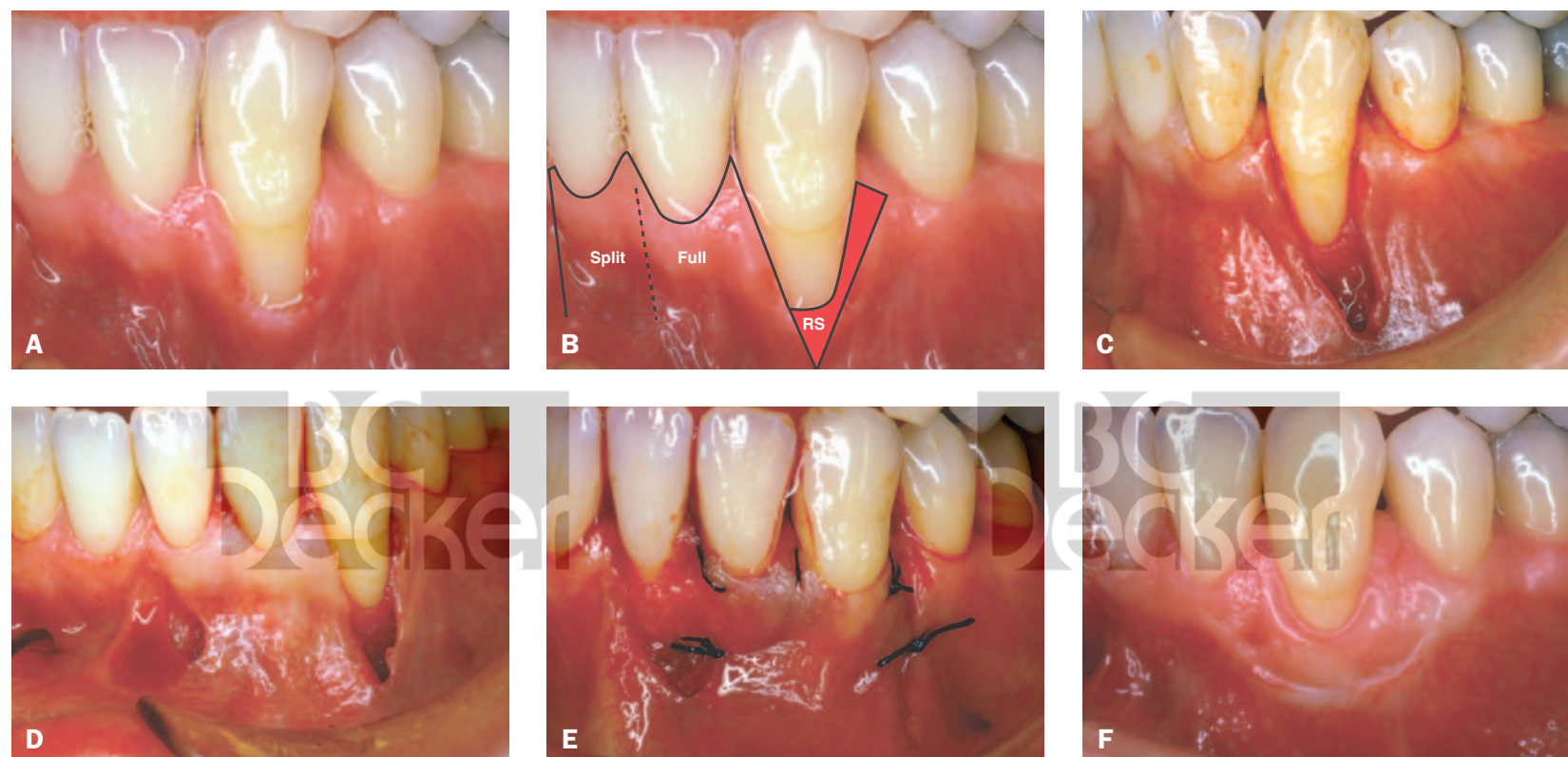


FIGURE 6-39. Partial-full-thickness laterally positioned flap. A, Before treatment. B, Outline of incisions for split-full-thickness pedicle flap. C, V-shaped incision completed at the recipient site. D, Partial-full-thickness pedicle flap outlined. E, Flap rotated over the recipient site. F, Seven months later. Compare with A.

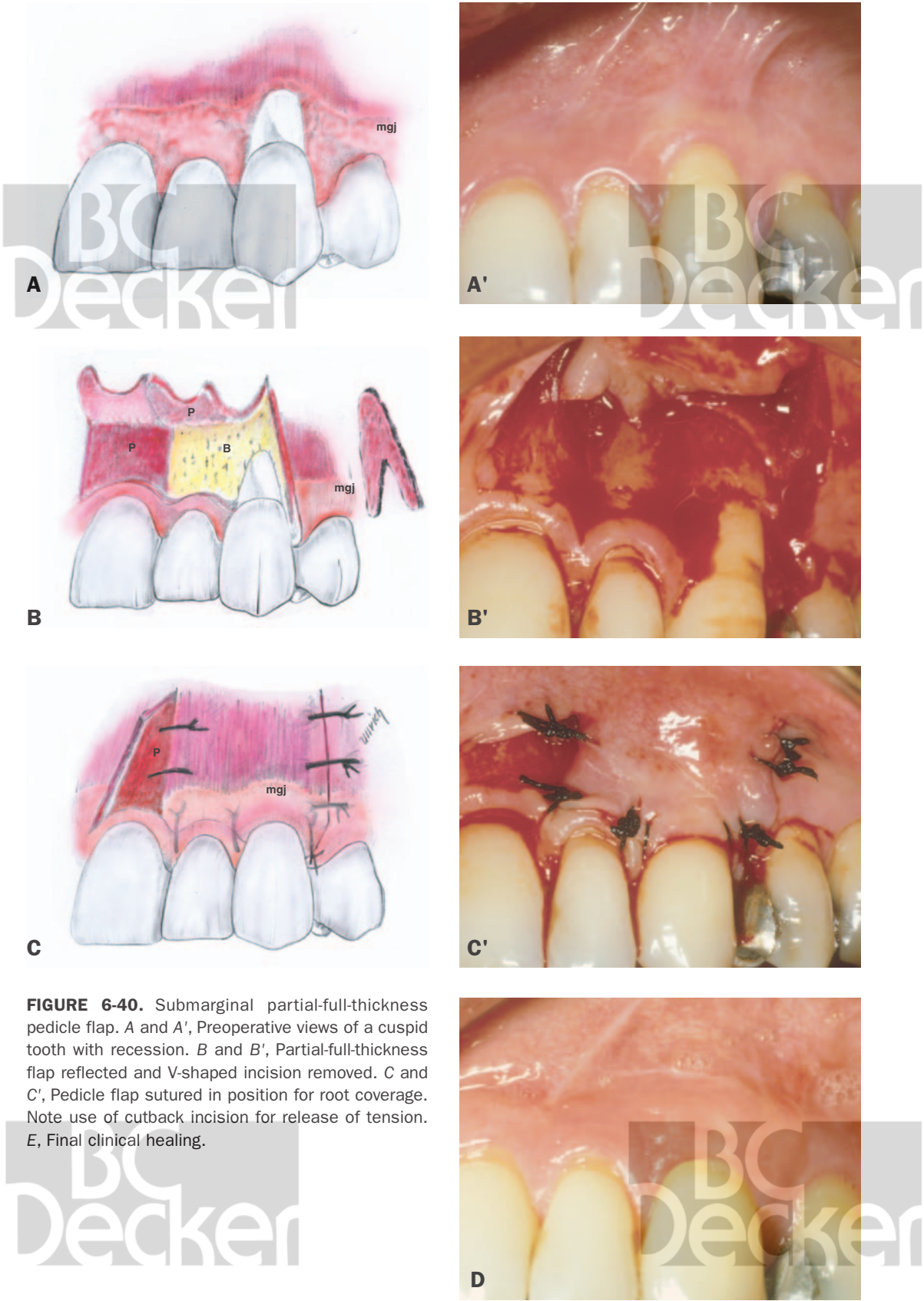


FIGURE 6-40. Submarginal partial-full-thickness pedicle flap. *A* and *A'*, Preoperative views of a cuspid tooth with recession. *B* and *B'*, Partial-full-thickness flap reflected and V-shaped incision removed. *C* and *C'*, Pedicle flap sutured in position for root coverage. Note use of cutback incision for release of tension. *E*, Final clinical healing.

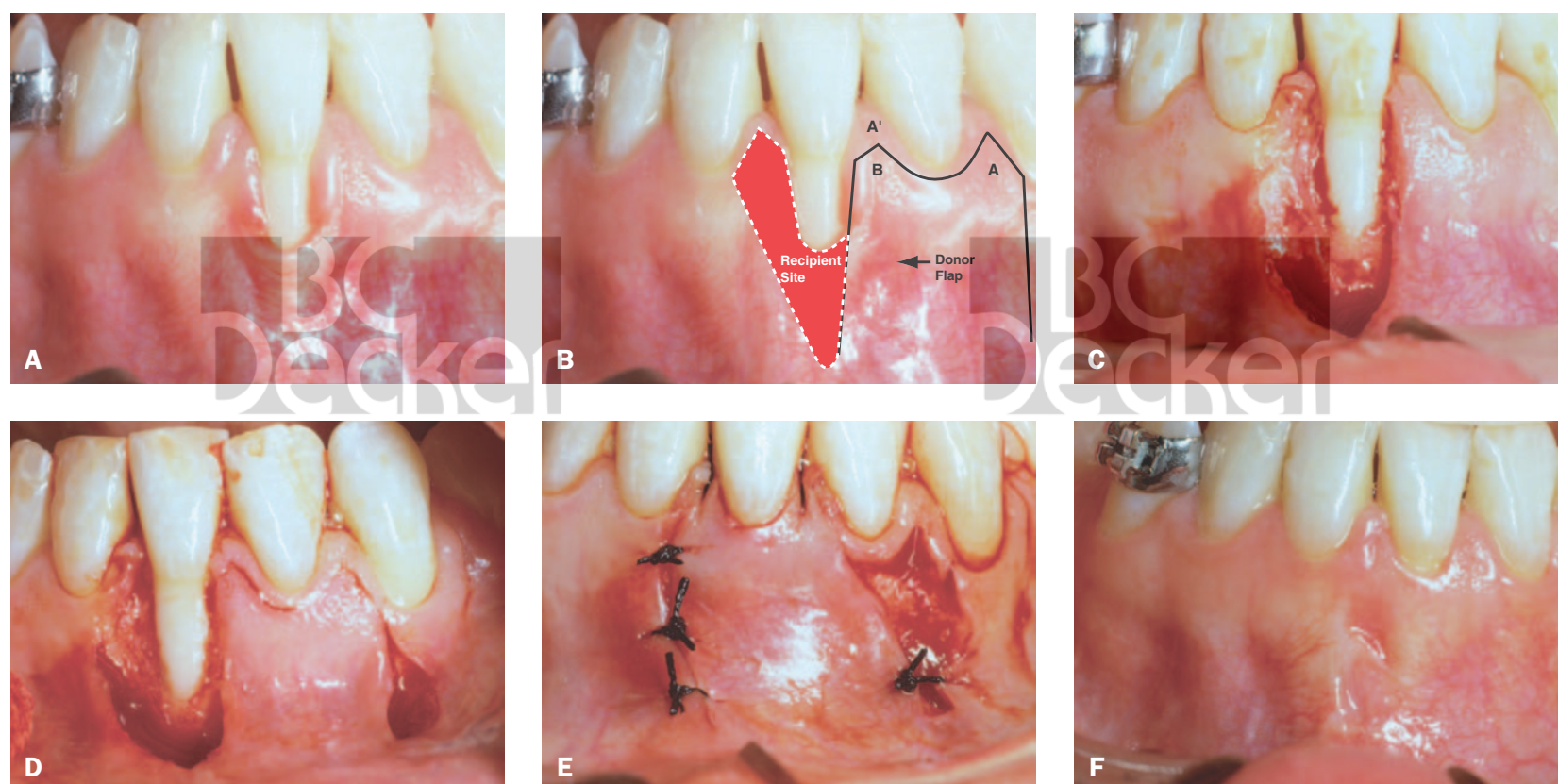


FIGURE 6-41. Submarginal pedicle flap. A, Before treatment. B, Outline of incisions: A positioned to A'; B positioned to B'. **Note:** If tension on the flap is present, a small cutback incision may be required. C, V-shaped incision removed and periosteal bed prepared. D, Pedicle and submarginal incisions outlined. E, Pedicle reflected by either blunt (full-thickness if bone is adequate) or sharp (partial-thickness if bone is thin) dissection and sutured laterally. F, Four years later, note the excellent result, with no shrinkage at the donor site.

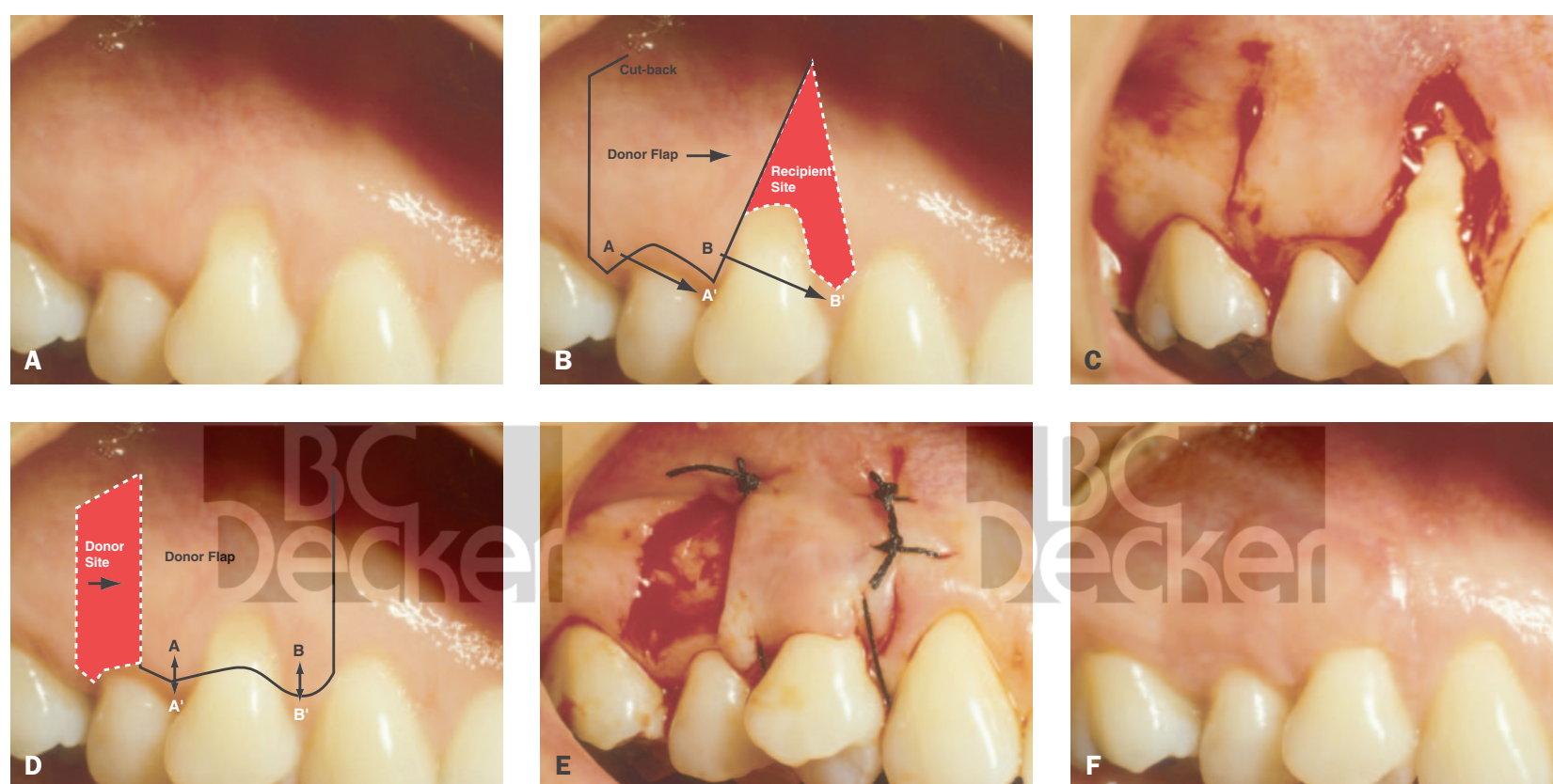


FIGURE 6-42. Full-thickness submarginal pedicle flap. A, Initial view of recession on tooth 5. B, Diagrammatic outline of incisions. C, Clinical view of the initial V-shaped recipient site. D, Diagrammatic view of the rotated flap. E, Clinical view of the rotated flap after suturing. Note the cutback incision. F, Final case. Note the lack of recession at the donor site.

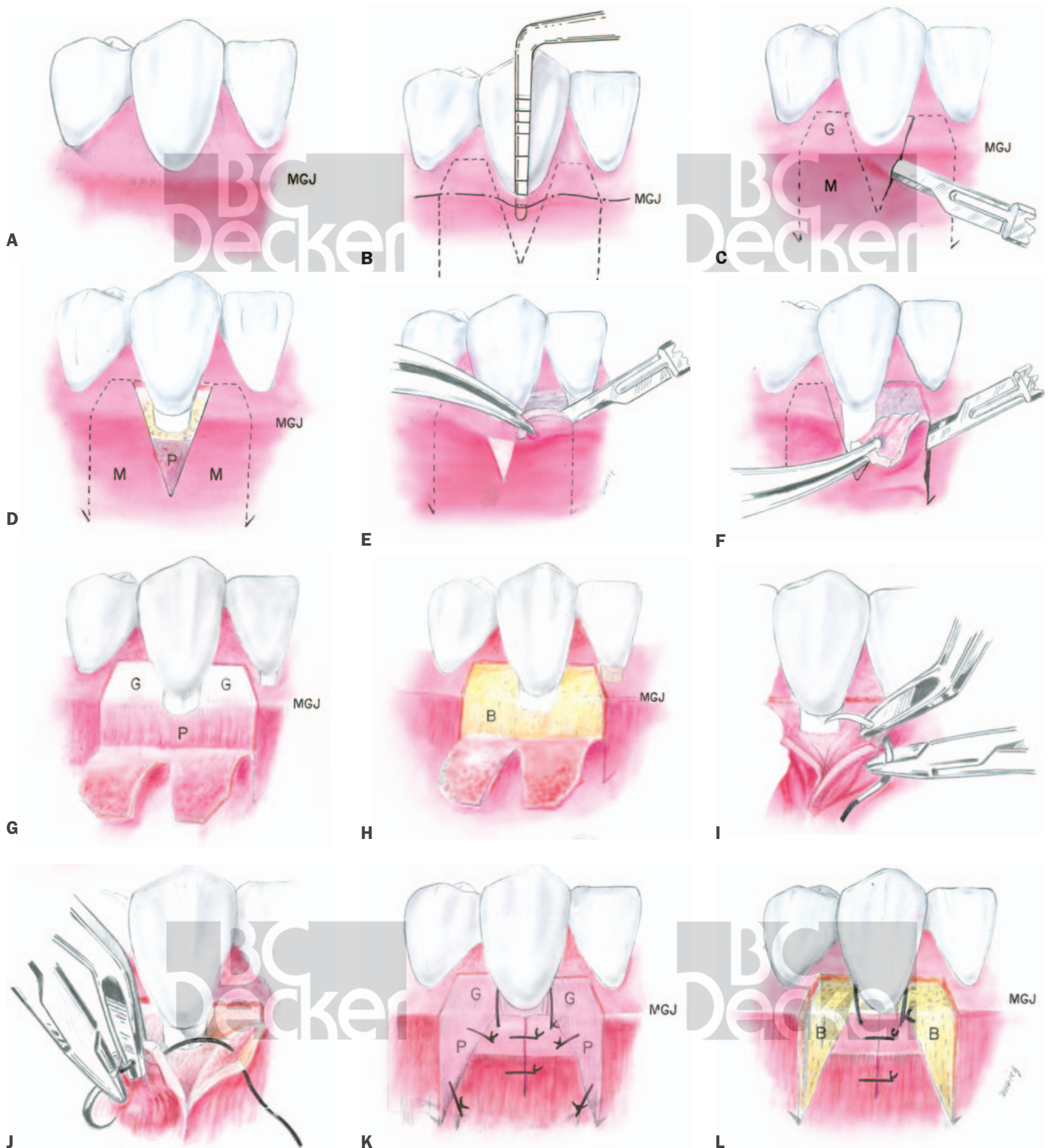


FIGURE 6-43. Double-papillae flap. A, Before. B, Incisions outlined and the probe in place, showing the mucogingival problem. C, V-shaped incision begun. D, V-shaped wedge removed. P = periosteum. E, Papillary flaps begun with occlusal aspect. F, Papillary flap completed with dissection in an apico-occlusal direction. G, Papillary flaps reflected with periosteum (P and G), left. H, Full-thickness papillary flaps reflected. I, Papilla held with Corn tissue pliers as suturing is begun. J, Initial suture passed through the papilla. K, Double-papillae flap sutured and stabilized. L, Final suturing of a full-thickness double-papillae flap.

flaps are lifted off the periosteum (the periosteum overlying the bone coronal to the mucogingival junction) (Figure 6-43G).

A full-thickness mucoperiosteal flap is occasionally used as a modification by which the underlying bone is exposed (Figure 6-43H). It is indicated when periosteal retention is difficult because of a mobile tissue base, but it is not the treatment of choice.

The tissue is now grasped with Corn tissue pliers, and the suture needle is passed through the outer surface of the first papilla (Figure 6-43I) and on through the undersurface of the second papilla (Figure 6-43J). Coaptation of the double-papillae flap is accomplished using 4-0, 5-0, or 6-0 silk or chromic gut suture with a P-3 atraumatic needle.

Special care must be taken to ensure that there is no separation of the flaps. Removal of the outer epithelium on one flap, allowing the two papillae to overlap with contact on their connective tissue surfaces, may be used to prevent separation.

Complete fixation of the flaps is accomplished by both sling and periosteal sutures (Figure 6-43K). If a full-thickness mucoperiosteal flap is used (Figure 6-43L), the lack of underlying periosteum permits only a sling suture, which makes movement and resultant failure possible.

Digital pressure is now applied for 5 minutes to aid initial adherence of the flaps to the under-

lying periosteum and to prevent the formation of a blood clot.

The complete procedure is shown clinically in Figure 6-44.

Variation for Root Coverage. Sometimes an isolated tooth has a denuded root surface that may or may not present a mucogingival problem. In this instance, it is sometimes desirable to try specifically to achieve root coverage for esthetic or prosthetic considerations.

The primary factor to consider is whether the papillae have an adequate amount of tissue; if the procedure fails, the tooth should still be left with a functional zone of attached tissue. Therefore, there must be enough attached tissue to (1) cover the denuded root surface and (2) cover part of the periosteum over the root.

In the illustrated and clinical examples, note the loss of gingiva on the facial aspect of the cuspid tooth (Figure 6-45, A and A'). Note also that a mucogingival problem is present only in the illustration (see Figure 6-45). The incisions (eg, lateral releasing or V-shaped) are accomplished in the same manner as described earlier (Figure 6-45, B and B'). Once the papillae have been freed, the teeth are thoroughly root planed to remove any calculus and necrotic cementum present, and the flaps are then brought together and

sutured (Figure 6-45, C and C'). Note that the flaps are actually brought 1 mm onto the enamel. This is to allow for shrinkage of the flaps as healing occurs. More importantly, note that the zone of attached tissue is wide enough to cover both the root surface and the periosteum adequately.

The complete clinical example is seen in Figure 6-46.

Common Reasons for Failure.

1. Adequate suturing is necessary to ensure proper healing in the desired position. Without adequate closure of the double-papillae flap, separation can occur, with possible nonunion of the component flaps. This is the most frequent cause of failure (Figure 6-47A).
2. The use of full-thickness flaps as opposed to the recommended split-thickness flap can lead to surgical failure if, after raising the full-thickness flap, dehiscence or fenestration of the osseous support is present. The failure will be unsightly exposure of the root surface (Figure 6-47B).
3. For the double-papillae flap procedure to be successful, it is imperative that adequate attached gingiva be available in the papillary area for transfer. Proper evaluation of the donor areas should be made prior to surgery

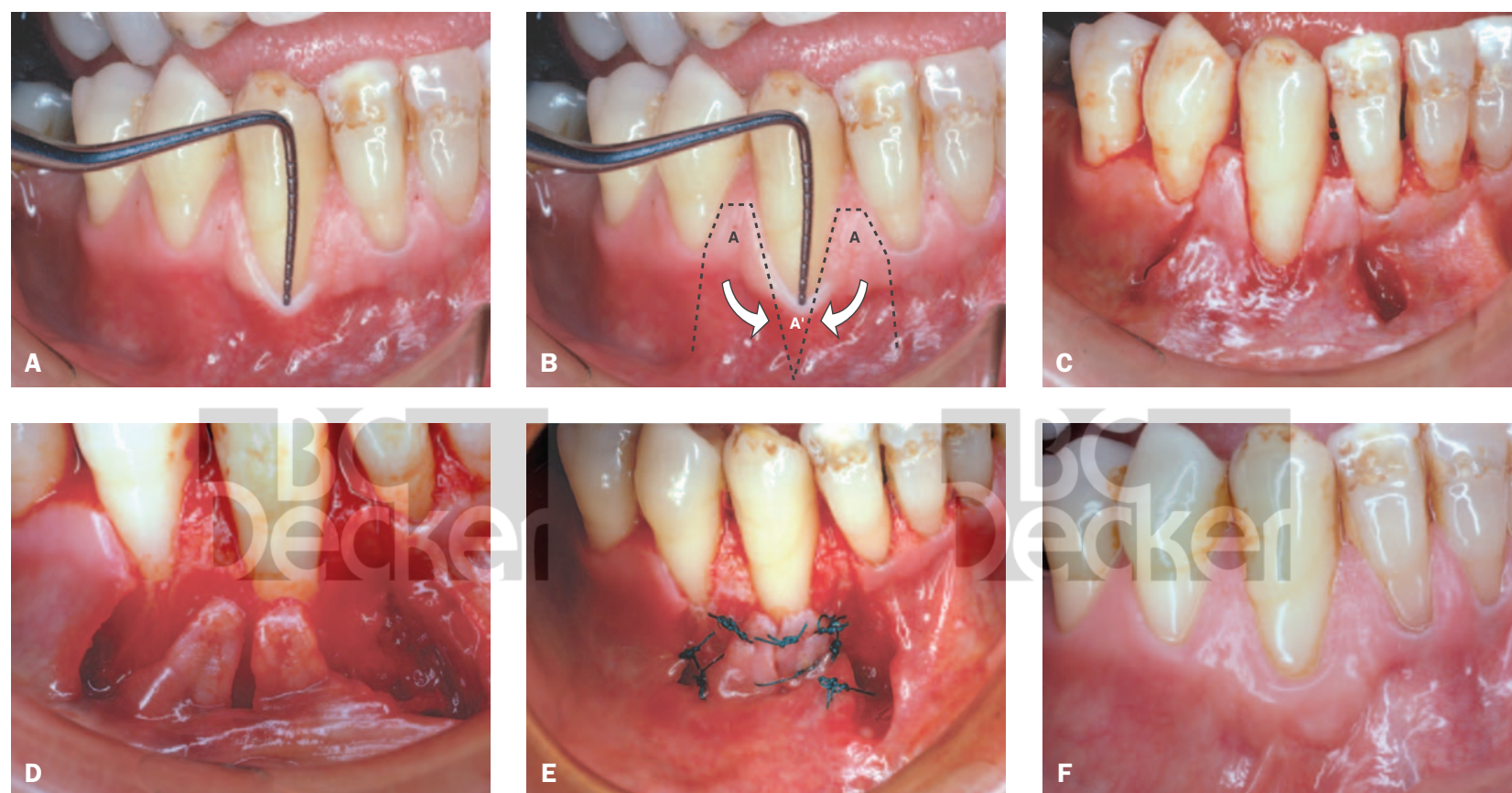


FIGURE 6-44. Double-papillae flap. A, Before. Probe showing a total lack of attached keratinized gingiva. B, Diagram outlining intended incisions and flap movement. C, Initial incisions and V-shaped incision complete. D, Papillae positioned for increasing the zone of attached keratinized gingiva only. E, Papillae sutured. F, Six months later.

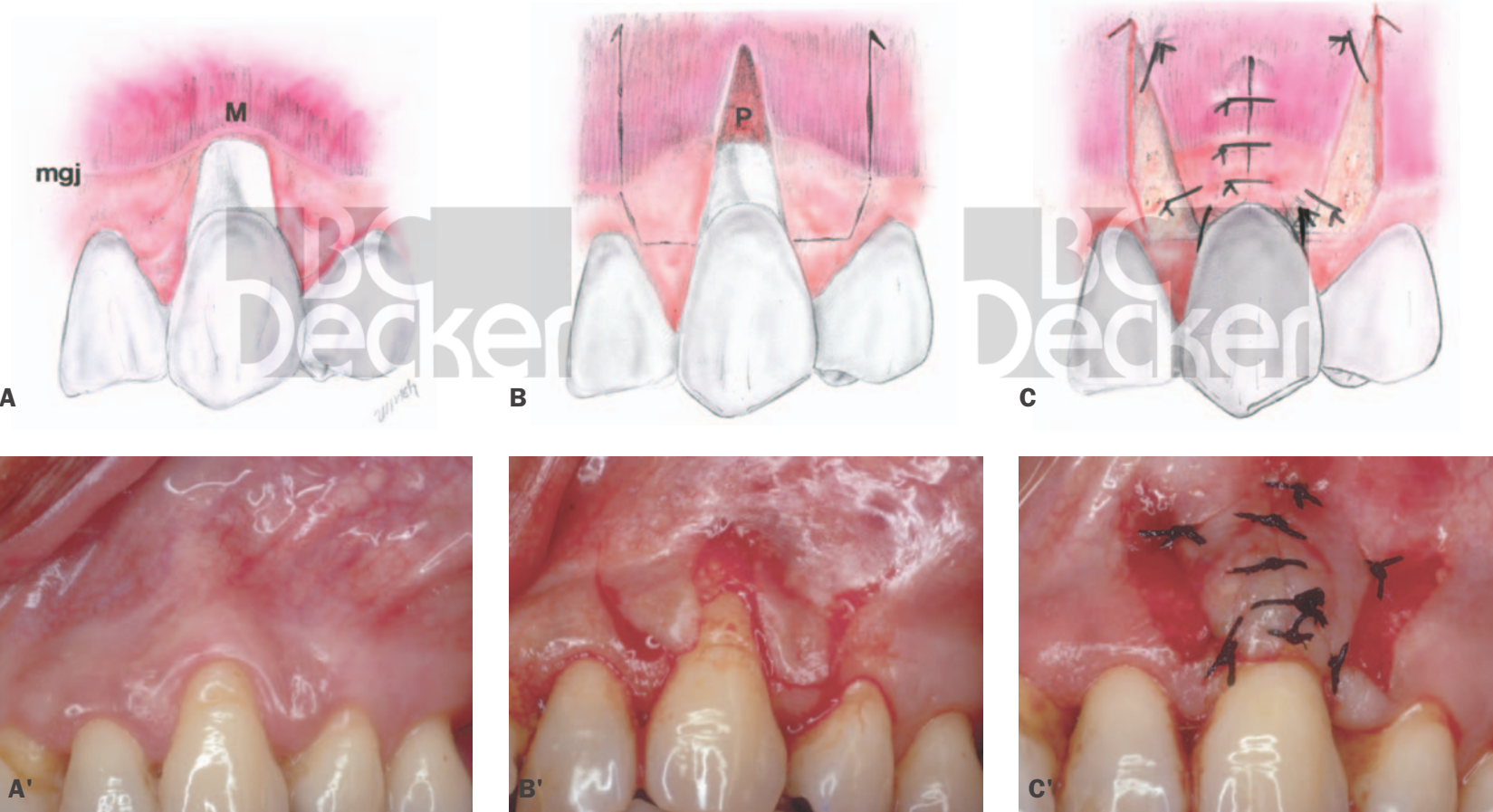


FIGURE 6-45. Double-papillae modification for root coverage. A and A', Before; cuspid shows recession. B and B', Incisions completed and V-shaped wedge of tissue removed. C and C', Double-papillae flap suture. Note overlap onto enamel and close approximation of papillae.



FIGURE 6-46. Double-papillae flaps for root coverage or increasing the width of keratinized gingiva. A, Initial view prior to increasing the zone of keratinized gingiva. A', Initial view prior to root coverage. B, Diagram showing apical positioning of papilla. B', Diagram showing lateral movement of papilla for root coverage. C, Papilla positioned and sutured apically at the cemento-enamel junction. C', Papilla positioned laterally and sutured above the cemento-enamel junction. D, Note the wide zone of keratinized gingiva. D', Sixth year postoperatively with 100% root coverage and an increased zone of keratinized gingiva.

so that another procedure may be done if necessary (Figure 6-47C).

4. Proper placement of the flap on the periosteal bed is necessary to ensure the success of the procedure. Note that the attached gingiva is placed only over the root surface and not over part of the periosteum. If the attached gingiva does not take on the root surface, the whole procedure will fail (Figure 6-47D).
5. Adequate fixation of the flaps to the underlying periosteum is necessary to prevent shift-

ing of the component flap tissues and the formation of a blood clot. Two sutures should be made at the base of the flaps to ensure fixation in the case shown in Figure 6-47E.

6. In the patient shown in Figure 6-47F, two additional sutures placed at the coronal aspect of the flaps but not at the base would have been the preferred procedure.

Horizontal Lateral Sliding Papillary Flap. Hattler (1967) outlined the use of a papillary flap for increasing the zone of keratinized attached gingi-

va. The procedure involved the movement of adjacent interdental papillae to the facial surface of teeth. Unlike the double-papillae flap procedure, which brings two papillae together, only a single papilla is used. This procedure is often combined with the subepithelial connective tissue graft for root coverage (see Ch. 21, *Cosmetic Root Coverage*).

The main limiting factor is the need for broad interdental papilla.

The technique is outlined in Figures 6-48 and 6-49.

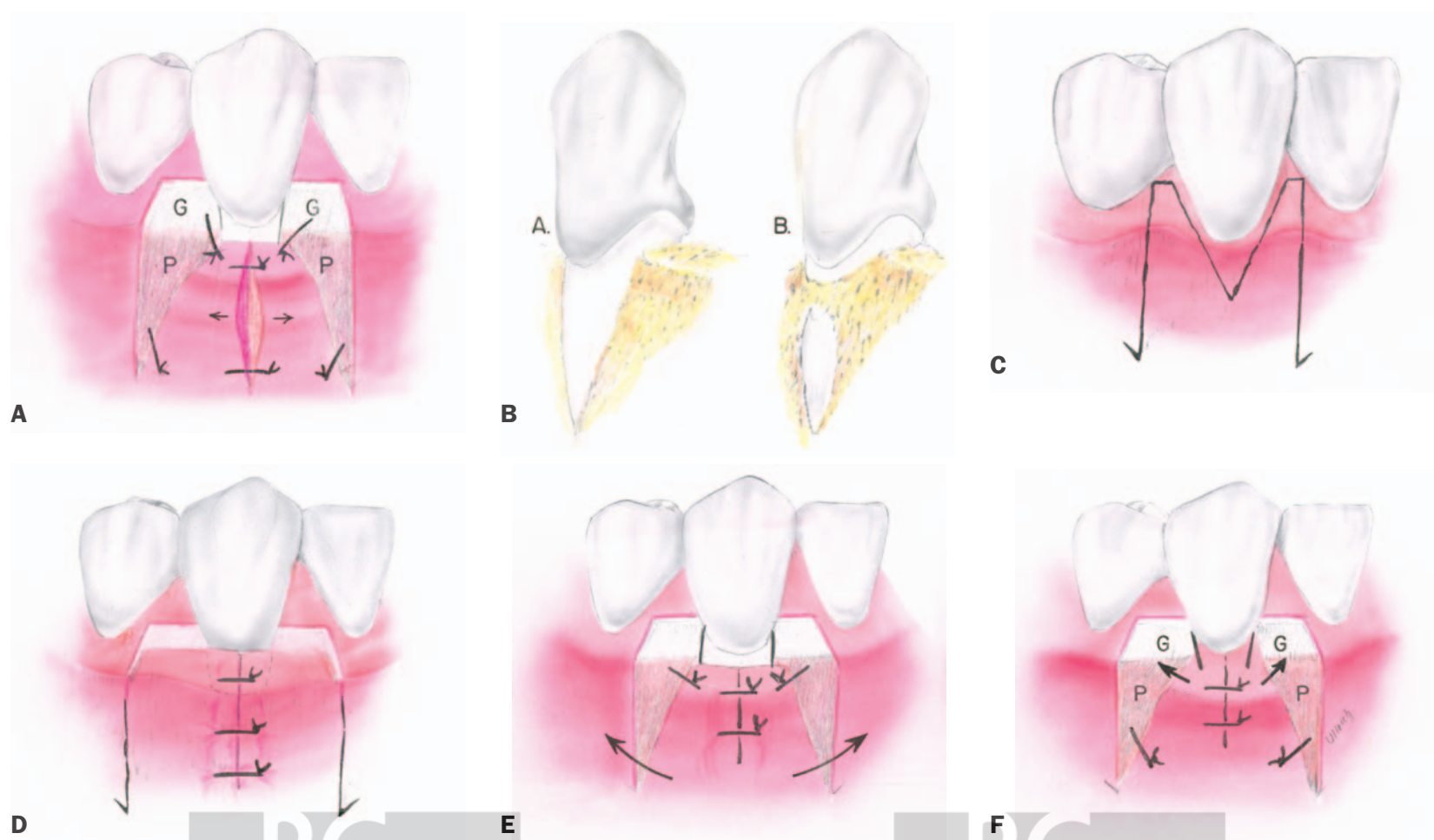


FIGURE 6-47. Double-papillae flap: reasons for failure. *A*, Separation of papillae as a result of inadequate suturing. *B*, Formation of dehiscence (*A*) or fenestration (*B*) with use of full-thickness flaps. *C*, Narrowness of papilla. *D*, Inadequate keratinized tissue present for root coverage. *E* and *F*, Flap movement because of inadequate stabilization.



FIGURE 6-48. Hattler rotated pedicle flap. A, Initial view. Note recession and lack of keratinized gingiva on teeth 12 and 13. B, Diagram outlining incisions and flap movement. C, Diagram of the final flap position. D, Clinical view of the final flap position. E, Two weeks postoperatively. F, Six months later. Note the wide zone of keratinized gingiva and apical movement of the muco-cutaneous junction. Compare with A.



FIGURE 6-49. Hattler rotated papillary technique for increasing the zone of keratinized gingiva. A, Initial view. B, Diagram of incision outline. C, Papillary flaps rotated and positioned with chromic sutures. D, Final result. Note the increased width of keratinized gingiva. This procedure can be combined with the supepithelial connective tissue graft or be used for coronally positioning a flap if root coverage is the objective.

Frenulectomy (Frenectomy) and Frenulotomy (Frenotomy)

The frenulum is defined as a small band or fold of mucosal membrane that attaches the lips and cheeks to the alveolar process and that limits their movements. When the frenulum is abnormal, in that it becomes capable of initiating periodontal disease by retracting healthy gingival margins, it must be removed. If an abnormal frenulum is left in place, it can result in the following (Corn, 1964a):

1. Gingival recession
2. Diastema formation
3. Accumulation of debris by reflection and opening of the sulcus

The frenulum must also be removed when it is so thick and wide that it may interfere with tooth brushing, thus promoting inflammation

and periodontal breakdown, or with orthodontic movement.

Frenulotomy is the simple excisional release of the frenulum from the apex of its insertion to its base and down to the alveolar process. Frenulectomy is the complete removal of the frenulum, including its attachments to the underlying alveolar process. Frenulectomy and frenulotomy can be performed separately as localized procedures or in conjunction with other procedures to increase the zone of attached gingiva.

Frenulectomy Procedure

The frenulectomy procedure is outlined in Figure 6-50.

Frenulotomy Procedure

Frenulotomy is rarely needed. A frenulotomy will more than serve if done thoroughly and

completely, even in extreme cases. It will also be less traumatic.

With the patient under adequate anesthesia, the surgeon releases the frenulum using the following procedure. Starting at the apex and using a no. 15 scalpel blade, the surgeon releases each side individually. The incisions at the base are extended adequately to allow proper tapering of the flap.

All tissue tags are removed. The periosteum over the alveolar process is scored with the scalpel blade but not removed. This disrupts any residual muscle fibers and promotes scarring.

The remaining alveolar mucosa just below the attached gingiva is removed. The underside of the lip is sutured closed with interrupted chromic gut sutures and then sutured down at the base. *Adequate suturing makes it impossible for the frenulum to re-form.*

The frenulotomy procedure is outlined in Figures 6-50 to 54.

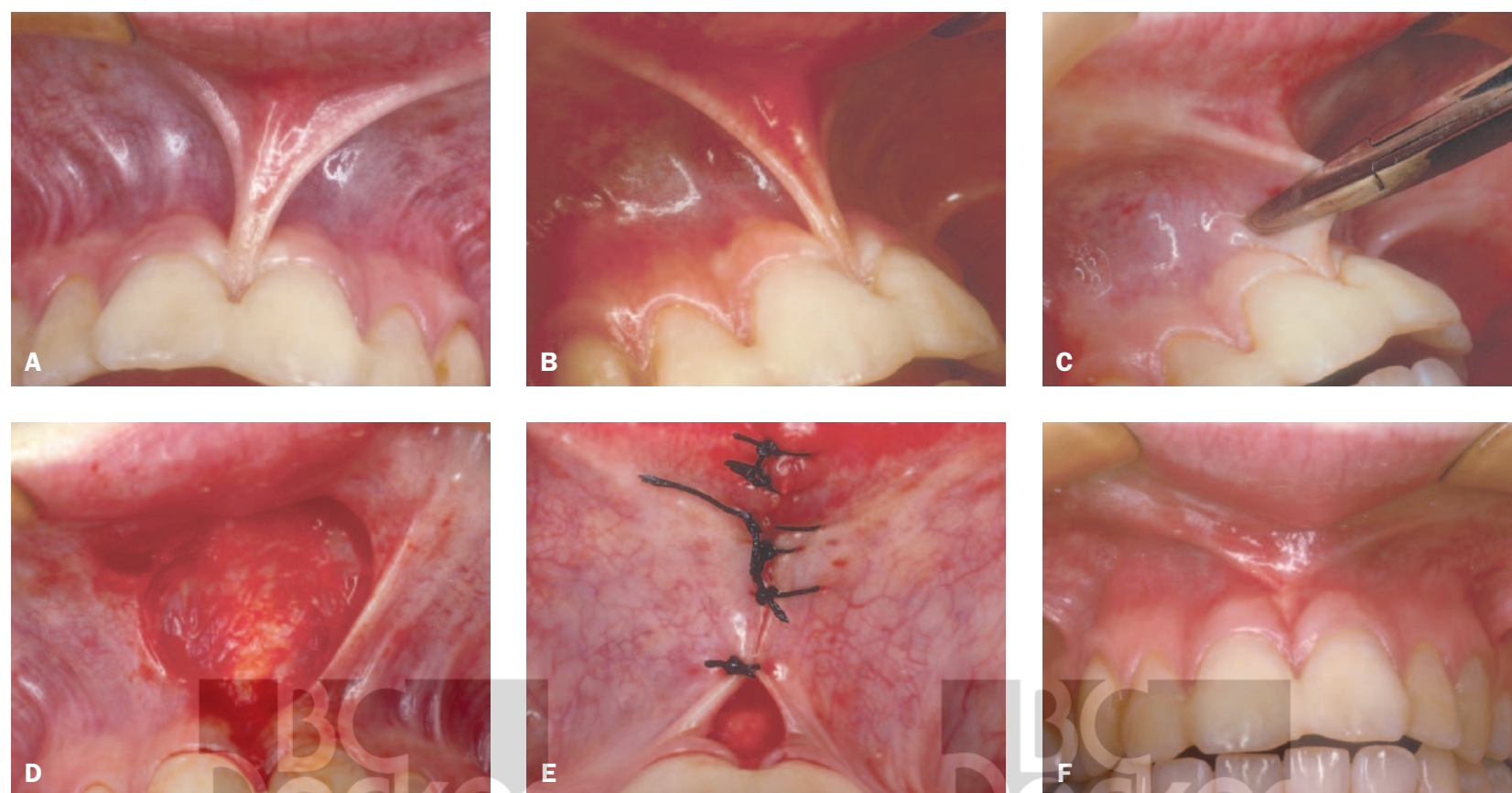


FIGURE 6-50. Frenulectomy (frenectomy). *A*, Before. *B*, Side view before. Note how high the frenulum attaches incisally. *C*, Hemostat holding the frenulum. Note the outline of incisions for excision of the frenulum. *D*, Incisions completed and frenulum removed. *E*, Tissue sutured. *F*, Case completed 6 months later.

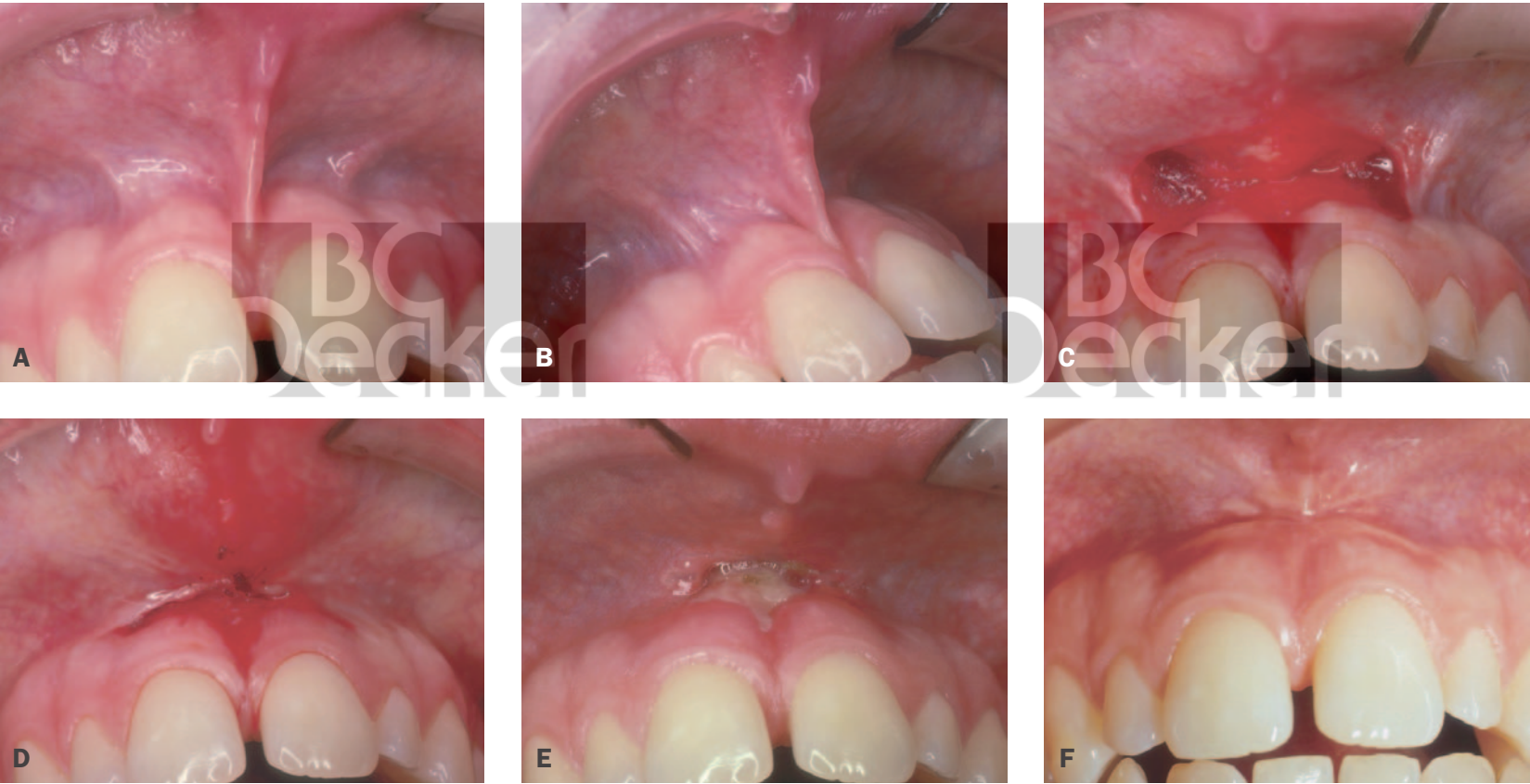


FIGURE 6-51. Frenulotomy (frenotomy). *A*, Before. *B*, Side view with outline of the incision for release of muscle. *C*, Tissue release. Note broad release of tissue even without total excision of tissue. *D*, Tissue suture with almost primary closure to reduce trauma and prevent muscle reattachment. *E*, One week later. *F*, Five months later. The result is excellent.

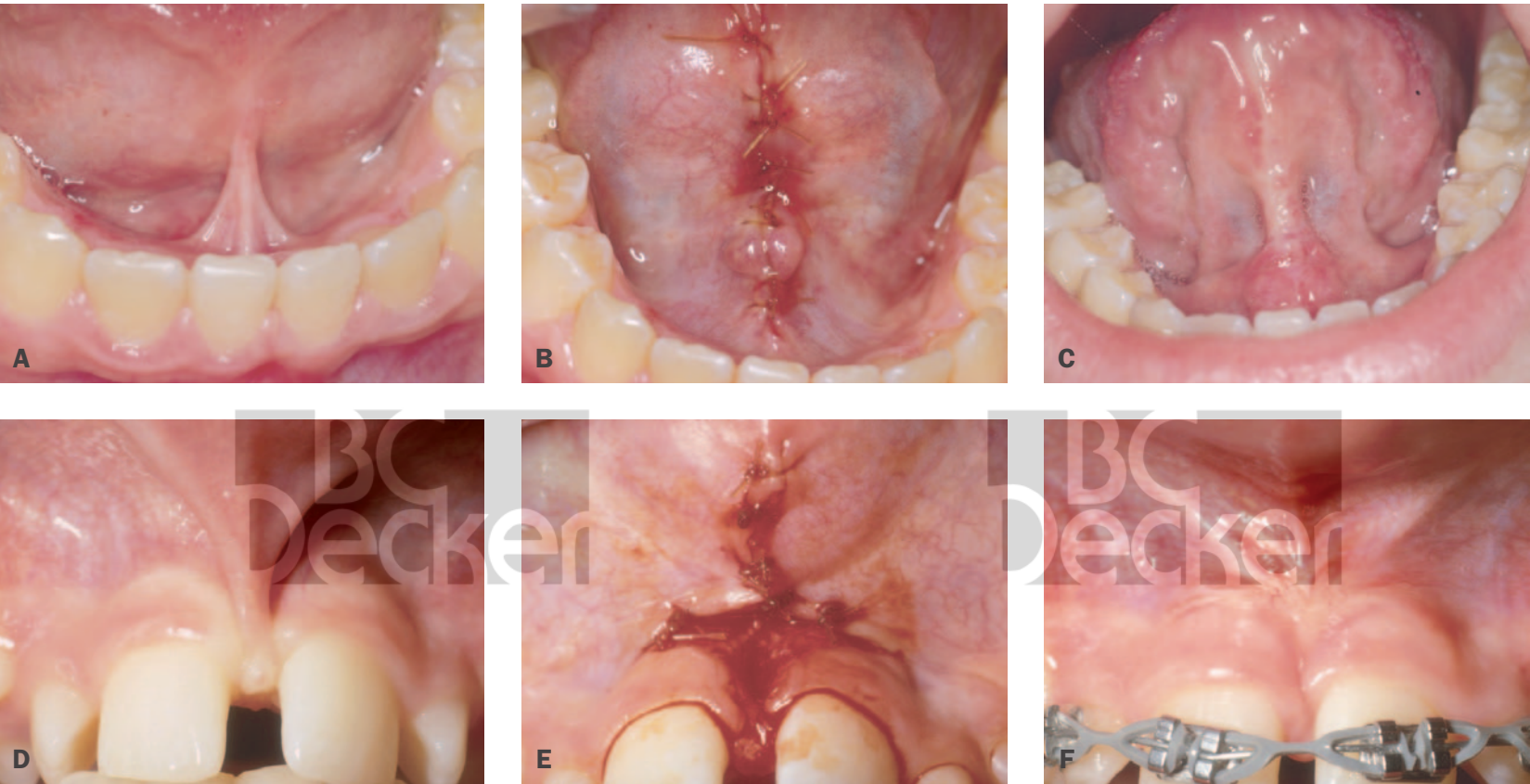


FIGURE 6-52. Frenulotomy (frenotomy). *A*, Initial view of lingual frenum. *B*, Frenum release and suturing with 4-0 chromic gut. *C*, Final healing. *D*, Large buccal frenum. *E*, Frenum released and sutured with 6-0 chromic gut. *F*, Final healing.



FIGURE 6-53. Frenulotomy (frenotomy) with free gingival graft. A and A', Preoperative clinical views with frenum (A) and recession (B). B and B', Free gingival graft positioned at CEJ and sutured. C and C', Final frenum displaced and wide zone.



FIGURE 6-54. Frenulotomy (frenotomy) with pedicle flaps. A and A', Gingival recession associated with frenum pull. B and B', Submarginal partial thickness pedicle graft. C and C', Final frenum displacement, root coverage, increased keratinized gingiva.



Palatal Flaps

The palate, unlike other areas, is composed mainly of dense collagenous tissue. This fact precludes the palatal tissue from being positioned apically, laterally, or coronally. Therefore, surgical techniques are required that allow the tissue to be thinned and apically positioned at the same time.

Historical Review

The palatal flap procedure historically involved reflecting a full-thickness flap to gain access to the underlying bone and remove necrotic and granulosomatous tissue. It was not until Ochsenbein and Bohannon (1963, 1964) described a palatal approach for osseous surgery that precise palatal surgical techniques were described and developed.

Figure 7-1 shows the outline of the three types of palatal flap designs: full-thickness flap (see Figure 7-1A, modified partial-thickness flap (see Figure 7-1B), and partial-thickness palatal flap (see Figure 7-1C). The objective and result of all three are the same: a thin, even-flowing gingival architecture that closely approximates the underlying bone (see Figure 7-1D).

Ochsenbein and Bohannon, in comparing the palatal and buccal approaches with osseous surgery, noted the following advantages, disadvantages, and indications of the palatal and buccal approaches.

Advantages of the Palatal Approach

1. Esthetics
2. Easier access for osseous surgery
3. Wider palatal embrasure space
4. A natural cleansing area
5. Less resorption because of thicker bone

Disadvantages of the Buccal Approach

1. Esthetics
2. Close root proximity
3. Possible involvement of the buccal furcation
4. Thin plate of bone overlying the maxillary molars where dehiscences and fenestrations may be present

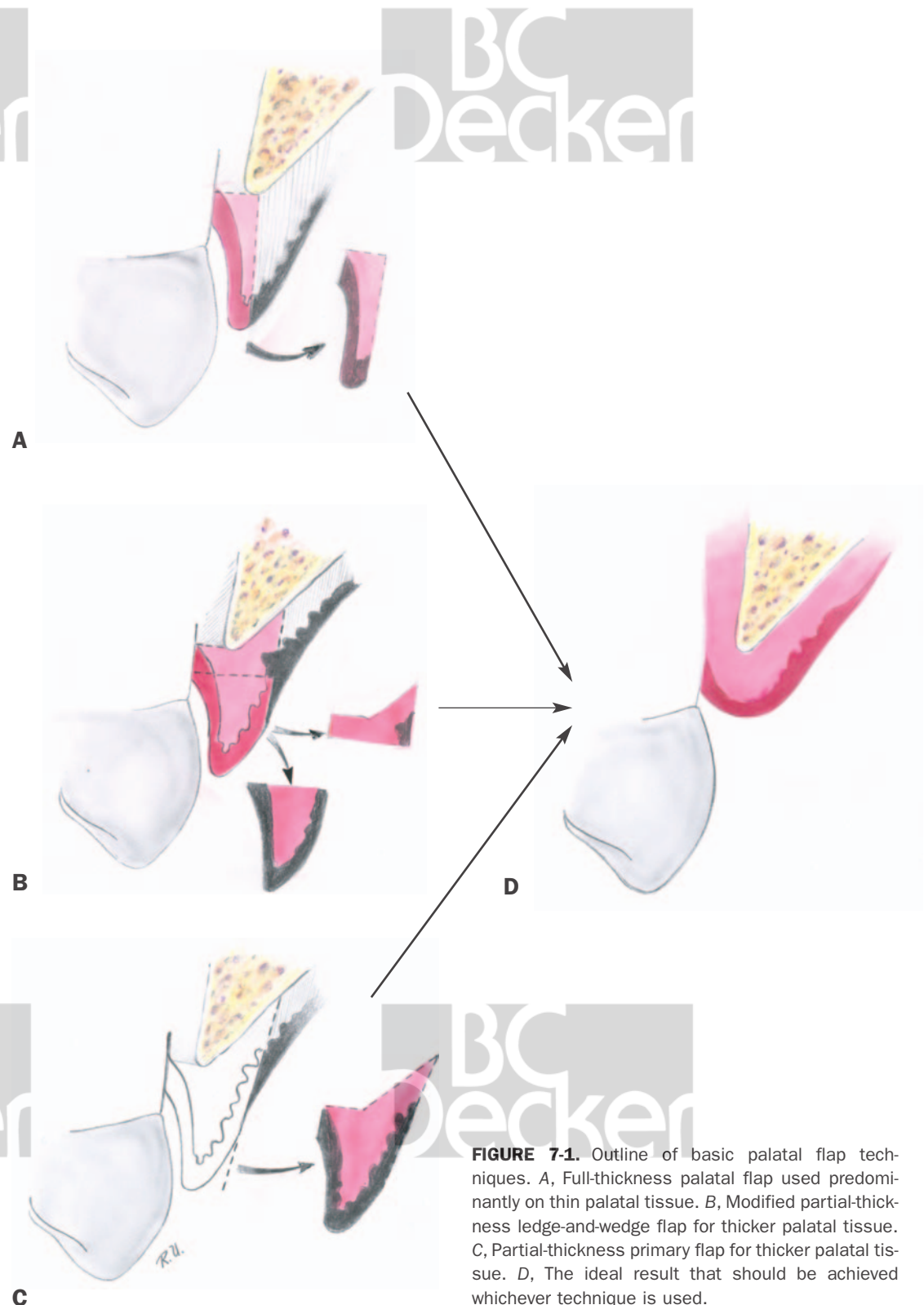


FIGURE 7-1. Outline of basic palatal flap techniques. A, Full-thickness palatal flap used predominantly on thin palatal tissue. B, Modified partial-thickness ledge-and-wedge flap for thicker palatal tissue. C, Partial-thickness primary flap for thicker palatal tissue. D, The ideal result that should be achieved whichever technique is used.

Indications

1. Areas that require osseous surgery
2. Pocket elimination
3. Reduction in enlarged and bulbous tissue

Contraindications

The palatal approach procedure is contraindicated when a broad, shallow palate does not permit a partial-thickness flap to be raised without possible damage to the palatal artery.

Diagnostic Probing

Before beginning the operation, but after adequate administration of anesthetic, periodontal probing or sounding for the underlying osseous topography is indicated (Easley, 1967). This is especially important on the palate, where frequently the tissue is enlarged and bulbous, with underlying heavy bone ledges and exostoses. These exostoses frequently occur in second and third areas (Figure 7-2).

Sounding permits one to discriminate between dense fibrotic tissue and enlarged tissue resulting from the osseous irregularities (Figure 7-3). Furthermore, because palatal tissue cannot be positioned, failure to access the underlying topography adequately often results in a flap that is either too long or too short. Tissue thickness is one of the determining factors for incision placement—the thicker the tissue, the more exaggerated the scalloping of the incision. A more exaggerated incision would also be needed if extensive osteoplasty was needed for reduction in and removal of heavy bony ledges and exostoses.

The various tissue-bone relationships and the anticipated incisions are reviewed in Figure 7-4. Note that even though the tissue appears to

be the same in all instances and the results may be the same, the incisions vary according to the underlying osseous topography.

Partial-Thickness Palatal Flap

This technique was developed by Staffileno (1969a) to overcome some of the problems of extensive gingival resection and to facilitate treatment of palatal osseous defects, which until then were approached cautiously.

Advantages

1. Minimal trauma
2. Rapid healing
3. Ease of palatal tissue manipulation
4. Establishment of favorable gingival contours

It is important to note that the partial-thickness palatal flap is a procedure that requires a high degree of technical skill and should be attempted only after some advanced training because the palatal artery can be damaged.

Resurgical Phase

With the patient under adequate anesthesia, the operator sounds for the underlying osseous topography. This is very important because the flap cannot be positioned after the initial incision. A short flap will result in bone exposure and a long flap will have to be trimmed, which is difficult and leaves thick marginal tissue.

The thicker the tissue, the more exaggerated the scalloping of the incision. For this reason, the exact thickness of the tissue must be determined at the start. Underlying osseous irregularities and osseous resection techniques must also be anticipated.

Once all of the factors have been taken into account, the exact placement of the incision is determined (Figure 7-5A). A sounding will help determine not only the amount of scalloping required but also the length and degree of tapering of the incision in an occlusoapical direction to allow proper positioning and adaptation of the flap (Figure 7-5A'). This is much more difficult than it appears.

Surgical Phase

The primary incision is made with a no. 15 (usually) or no. 12 (if access is limited) scalpel blade. It is usually begun at the margin of the last tooth in the tuberosity area as an extension of the distal wedge procedure. It is continued forward, using a scalloped, inverse-beveled, partial-thickness incision to create a thin partial-thickness flap (Figure 7-5B').

The blade of the scalpel should always be kept on the vertical height of the alveolus. This prevents unnecessary involvement or cutting of the palatal artery.

When the tissue is thick, bulbous, or enlarged, it is often difficult, if not impossible, to make this first incision all the way down to the bone. The incision will have to follow the contour of both the tissue and underlying osseous topography.

Once the initial part of the primary incision has been completed, the tissue may be retracted with rat-tail pliers for completion of the incision (Figure 7-5, C and C'). On completion, the scalpel blade is directed toward the bone to score it at the base of the flap. This separates the periosteum in this area and permits easy removal of the secondary flap from bone. Without this scoring, it is more difficult to remove the secondary inner flap and generally results in a torn, ragged periosteal tissue with many tags.

A secondary sulcular incision is now completed both facially and interproximally using a no. 15 or no. 12 scalpel blade down to the crest of bone (Figure 7-5, D and D'). This incision frees the coronal aspects of the inner or secondary flap, permitting removal.

Ochsenbein chisels (nos. 1 and 2) are now used from both the occlusal and apical extensions of the flap to completely free and remove the secondary inner flap (Figure 7-5, E and E'). The no. 1 chisel is directed from the occlusal direction against the bone, lifting off or separating the periosteum of the secondary inner flap from the bone. The no. 2 chisel is placed in the scoring incision at the base of the primary thinning incision and, directing it occlusally, is used to remove the secondary inner flap. If the periosteum has not previously been scored, this procedure will be more difficult and will leave a torn, ragged periosteum. A Friedman rongeur may also be used to remove the secondary inner flap.

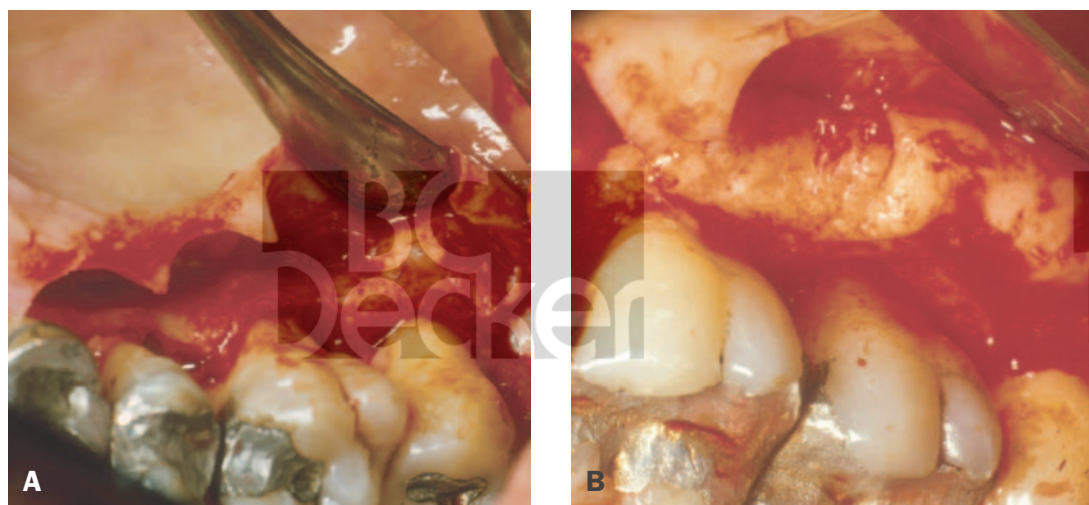


FIGURE 7-2. Palatal exostosis. Usually found in the second and third molar areas.

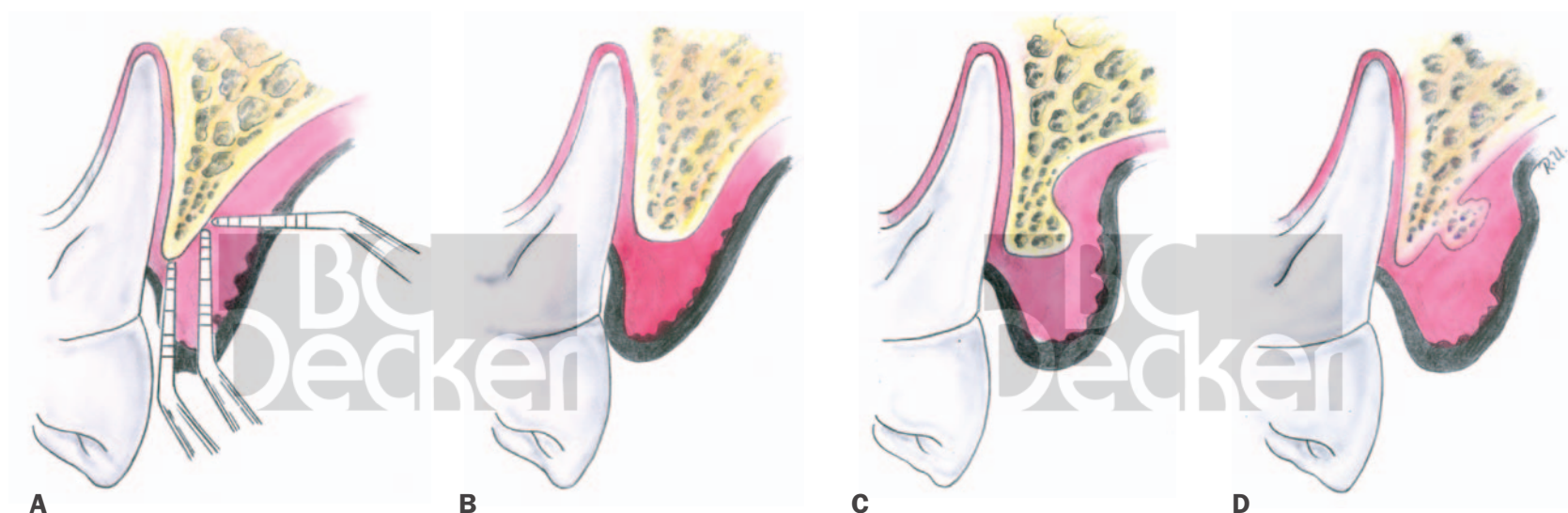


FIGURE 7-3. Periodontal sounding for the underlying osseous topography and common osseous irregularities. *A*, Periodontal probes inserted both vertically and apically not only to determine osseous defects interproximally but also to determine the thickness and height of alveolar bone and the presence of irregularities. *B*, Thick bony margins. *C*, Heavy bony margins. *D*, Exostoses.

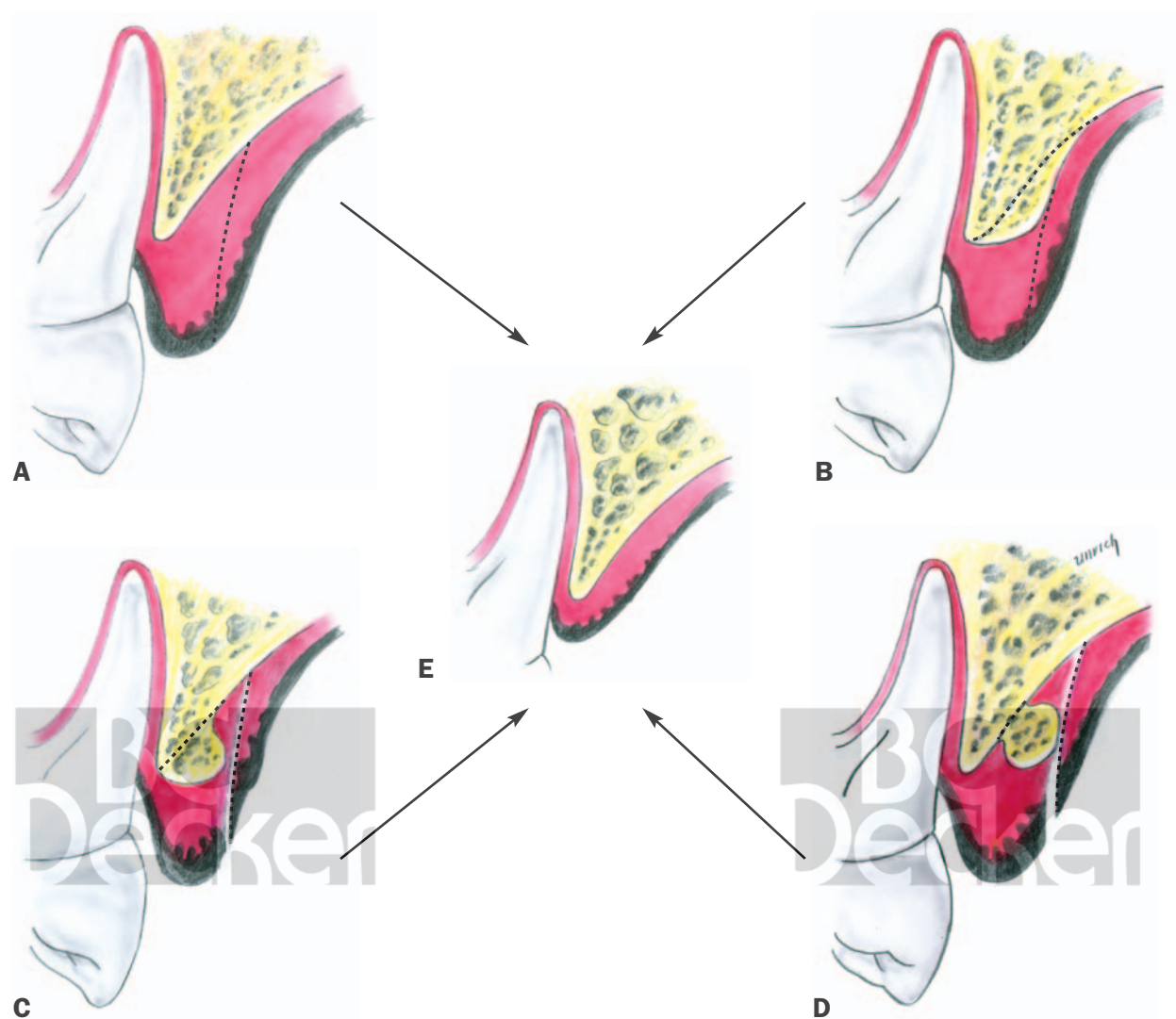


FIGURE 7-4. Variations in tissue-bone relationships. Note that even though the palatal tissue is the same, the incision varies with changes in the underlying osseous topography and the nature and extent of the osseous contouring required. The *dotted lines* indicate the flap design and osseous recontouring required in each instance to achieve an ideal form. *A*, Tissue enlargement only. *B*, Thickened palatal bone. *C*, Heavy bone margins. *D*, Exostoses. *E*, Final ideal form that should be attained by all.

Once the secondary inner flap has been removed and all necessary scaling and root planing and osseous surgery have been completed, the flap is allowed to fall back against the bone, and it is then sutured. If the design was proper, the flap will be at the crest of bone with

the scalloped papillae positioned interproximally, permitting primary closure (Figure 7-5, F and F'). Either interrupted or suspensory sutures can be used.

It is important to note that the inner 2° flap of connective tissue that has been removed can

now be trimmed and used for a free connective tissue autograft (Edel, 1974) or as part of a subepithelial connective tissue graft (Langer and Calagna, 1980; Langer and Langer, 1985).

The procedure is shown clinically in Figures 7-6 and 7-7.

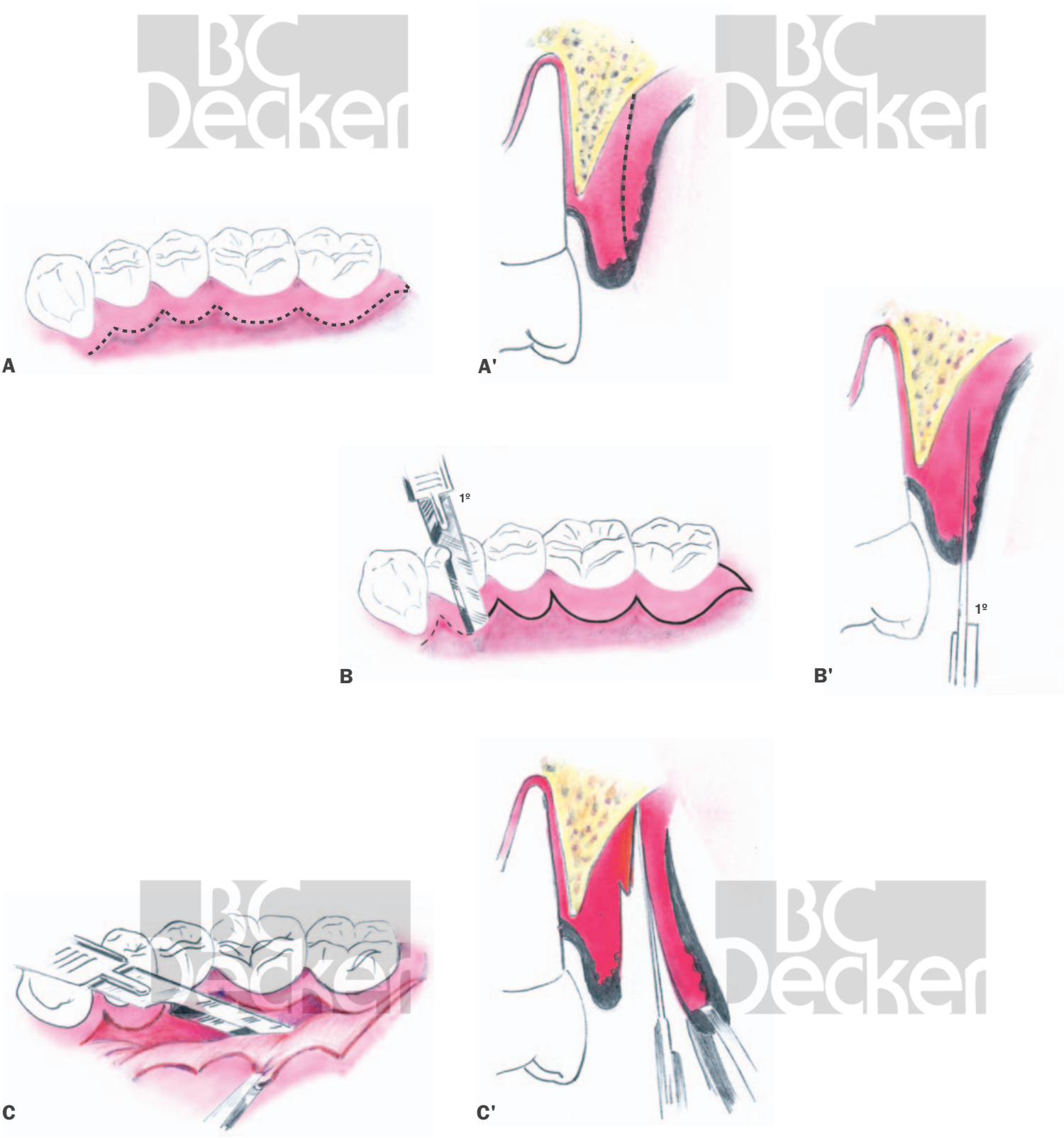


FIGURE 7-5. Primary partial-thickness palatal flap. A, Outline of primary initial scalloped incisions on the palate. A', Cross-sectional view of primary thinning incision. B, Primary scalloped incision is begun. B', Cross-sectional view shows that in thick palatal tissue it is not always possible to go straight down to the bone. C and C', Tissue pliers may be used to reflect the palatal flap as the incision is carried down to the bone, severing the periosteum at the base. **Note:** The primary incision is used to thin and shorten the flap at the same time.

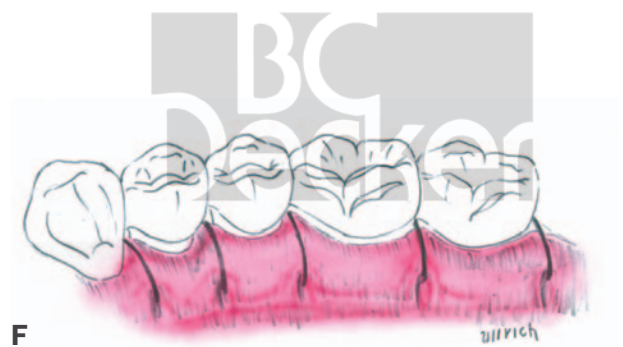
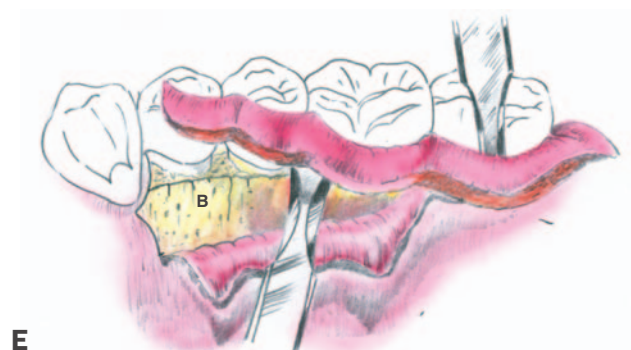
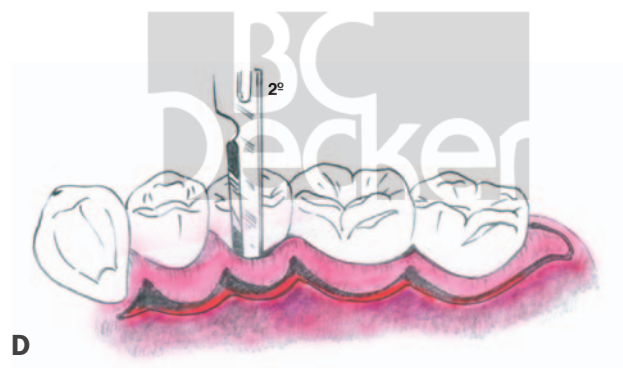


FIGURE 7-5. Continued. *D*, A secondary, sulcular incision is now made to free the inner flap prior to removal. *D'*, The sulcular incision is made to the crest of bone. *E* and *E'*, Ochsenein chisels are used to loosen and lift the inner flap for removal and bone exposure. *F* and *F'*, The thinned and shortened flap is positioned over the bone and sutured interproximally.

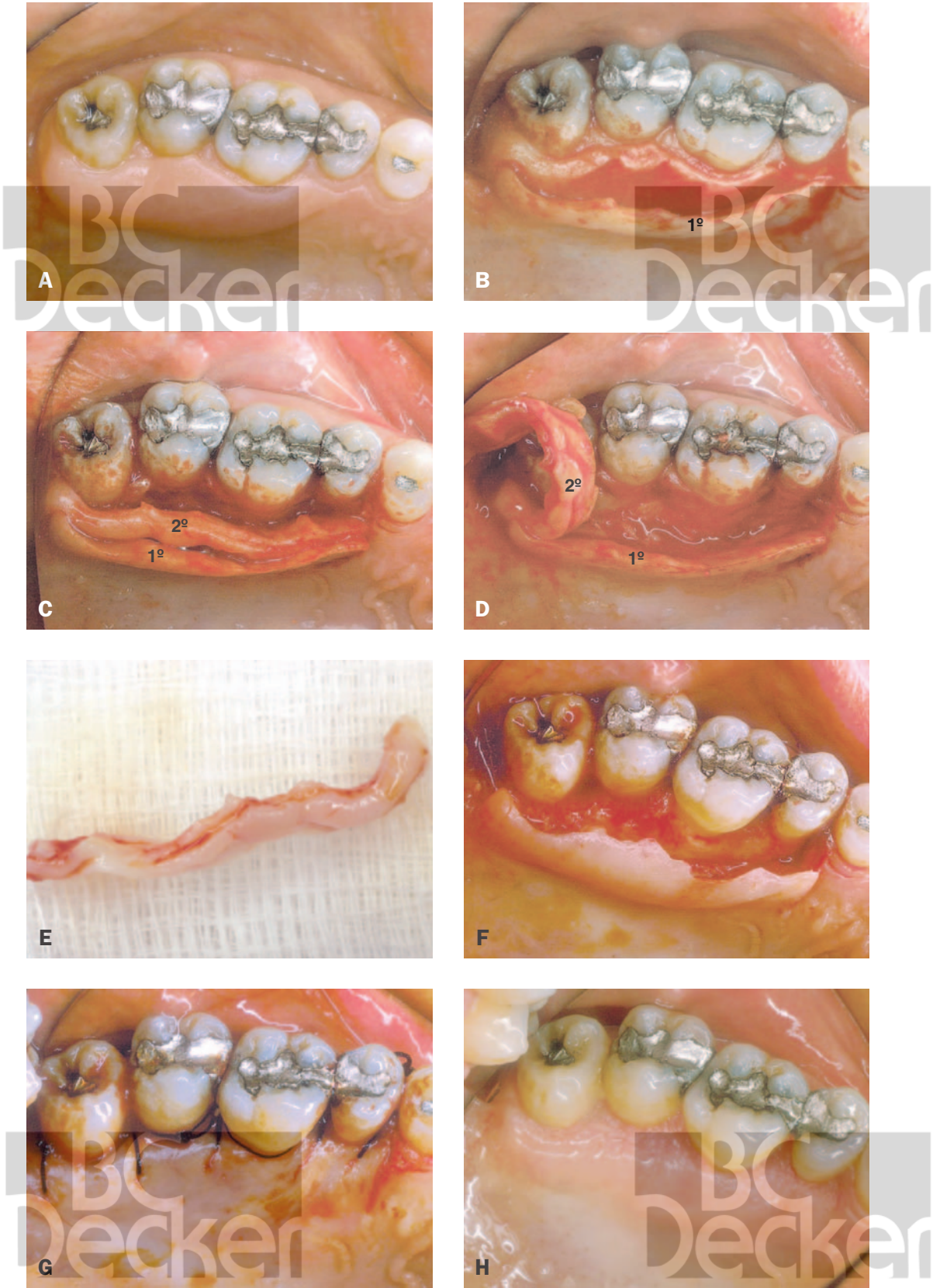


FIGURE 7-6. Partial-thickness palatal flap. *A*, Before, showing bulbous, enlarged tissue. *B*, Primary flap (1°) reflected. *C*, Secondary flap (2°) reflected. *D*, Removal of secondary inner flap. *E*, Secondary inner flap removed. *F*, Osseous contouring completed. *G*, Flap sutured. *H*, Seven months later. Note thin palatal contour with teeth fully exposed. Compare with *A*.

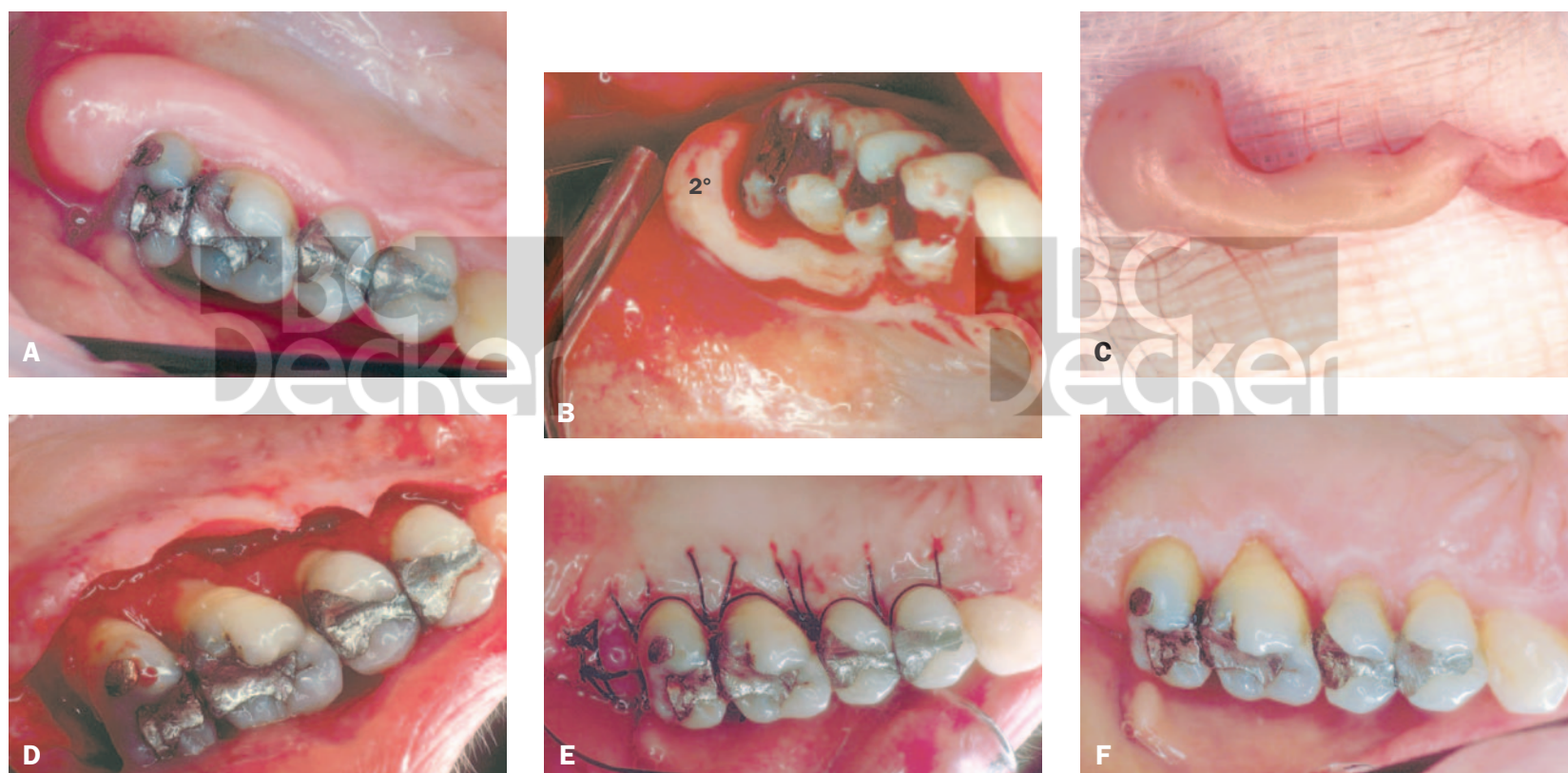


FIGURE 7-7. Partial-thickness palatal flap. A, Preoperative palatal view showing severely enlarged bulbous tissue. B, Initial inverse-beveled incision completed and secondary (2°) flap outlined. C, Secondary flap removed. Note the extreme bulbousness of the tissue. D, Flaps reflected and distal wedge removed. E, Flap sutured with primary closure. F, Eight months later; compare with A.

Modified Partial-Thickness Palatal Flap

Ochsenbein in 1958 and Ochsenbein and Bohanan in 1963 described this technique, but it was not until 1965 that it became popularized by Prichard. It has also become known as the ledge-and-wedge technique.

This is a two-stage procedure that is technically easier than the single-step partial-thickness palatal flap. It has as its main disadvantage the fact that healing interdentally is by secondary intention. This fact precludes the use of this procedure with such procedures as the modified Widman flap, excisional new attachment procedure, osseous grafting, and any others that require primary closure. This procedure also requires a certain degree of technical skill or the palatal artery can be damaged easily.

Presurgical Phase

With the patient under adequate anesthesia, sounding is carried out to determine the underlying osseous topography, pocket depth, and thickness of the tissue. This stage is not as critical as it is in the single-stage procedure because the first-stage gingivectomy incision will allow visualization of tissue thickness.

Surgical Phase

Stage I: Gingivectomy. It is not necessary to mark the base of the pockets with pocket markers. A periodontal probe may be used to estimate pocket depth (Figure 7-8, A and A'). A periodontal knife is used to resect tissue above the crest of bone (Figure 7-8, B and B'). Unlike the basic gingivectomy technique, *no bevel is placed*. A tissue ledge is established to allow visualization of tissue thickness and permit easier placement of the primary palatal incision (Figure 7-8, C and C').

Sometimes it may not be desirable to make the gingivectomy incision down to the base of the pocket, especially on thicker tissue. When such tissue is thinned and falls back against the bone, it will be short of the bony crest. This can result in excessive bone exposure and a good deal of postoperative discomfort.

A scalloped-type gingivectomy incision has sometimes been advocated to achieve interproximal primary closure. This is not recommended because the results are not satisfactory and primary closure is not attained.

Stage II: Partial-Thickness Flap. Once the gingivectomy procedure is complete, the remainder of the procedure is similar to that already described for the partial-thickness palatal flap.

A primary partial-thickness thinning incision is now completed down to the bone (Figure 7-8, D and D'). *This incision stays within the vertical height of the alveolus to avoid involvement of the palatal artery.* A scoring incision is used at the base of the flap to permit periosteal release of the secondary inner flap. A secondary incision about the neck of the teeth and interproximally is completed down to the crest of bone (see Figure 7-8, D and D'). Ochsenbein chisels (nos. 1 and 2) or a Friedman rongeur is used for occlusal and apical release of the secondary inner flap (Figure 7-8, E and E') and exposure of bone. Scaling, root planing, and osseous resection procedures are carried out, and the flap is sutured with interrupted or continuous sling sutures at or just above the crest of bone (Figure 7-8F'). The procedure is shown clinically in Figures 7-9 and 7-10.

Common Mistakes

1. The short flap. This is generally the result of too deep a primary incision, gingivectomy to the crest of bone of a thick tissue, or use of a beveled gingivectomy (Figure 7-11A). This results in delayed healing and increased patient discomfort.
2. Poor marginal flap adaptation caused by

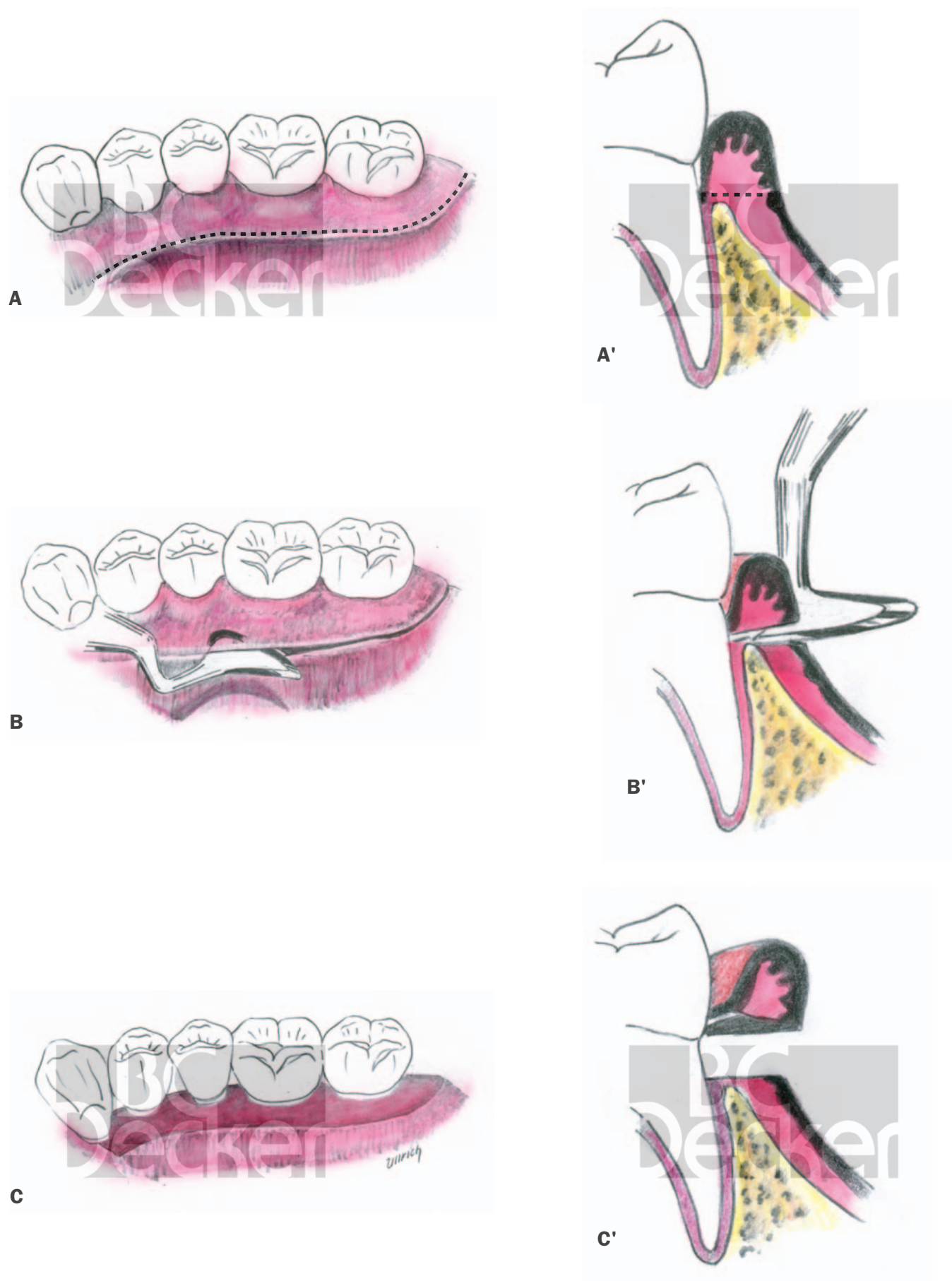
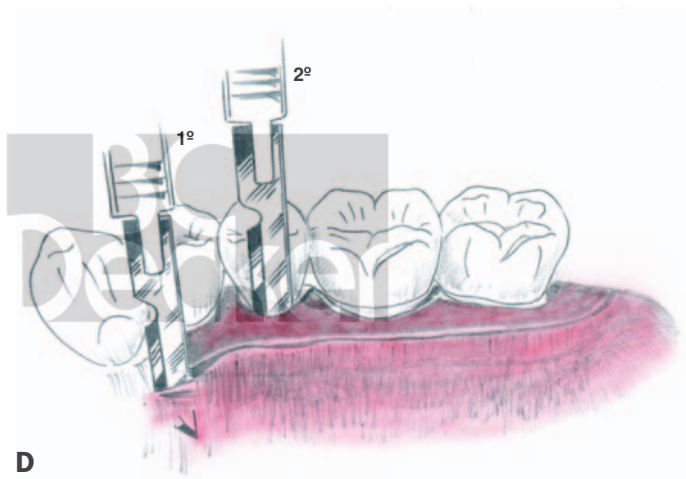
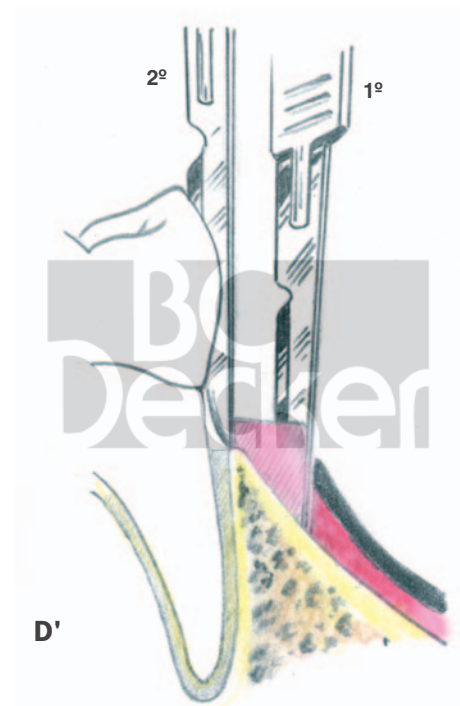


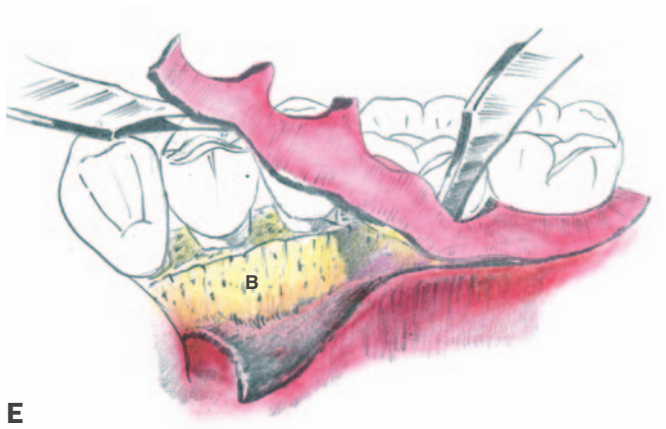
FIGURE 7-8. Modified partial-thickness or ledge-and-wedge palatal flap. A, Outline of initial gingivectomy incision. A', Cross-sectional view showing a nonbeveled initial gingivectomy incision above the bone. B and B', The initial gingivectomy incision is carried out using periodontal knives. C and C', Removal of the excised tissue and creation of a flat tissue ledge. Note that the tissue ledge allows the clinician to determine more easily the primary thinning incisions.



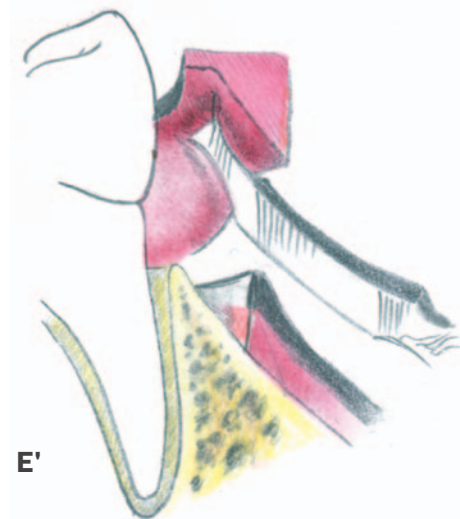
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D'



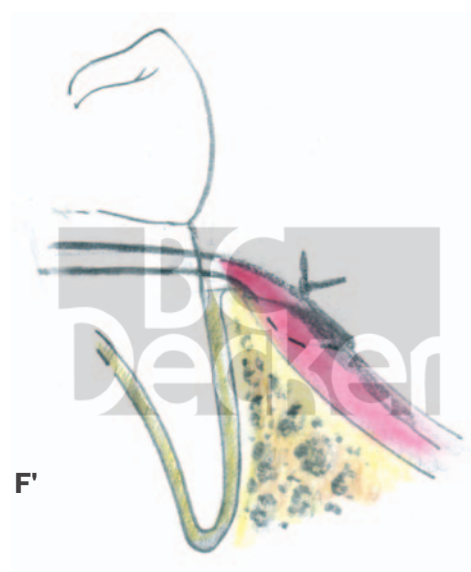
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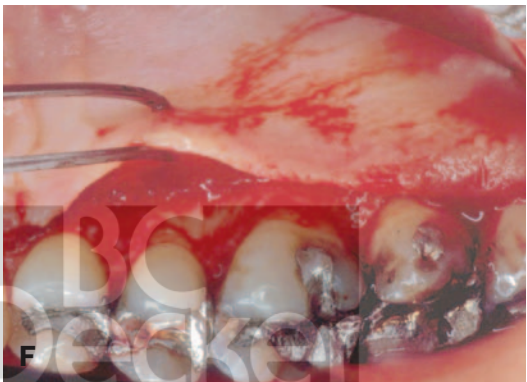
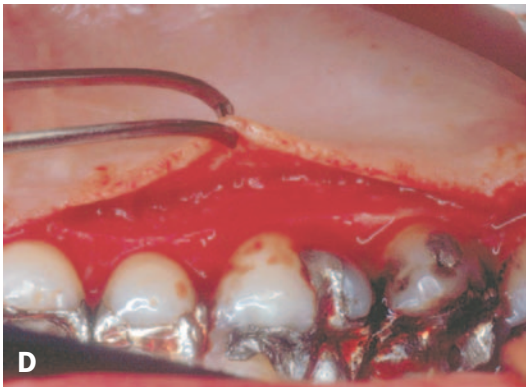
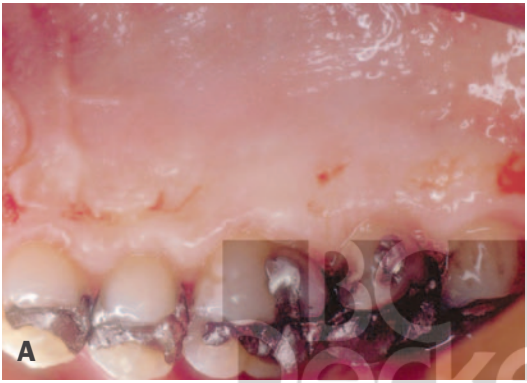
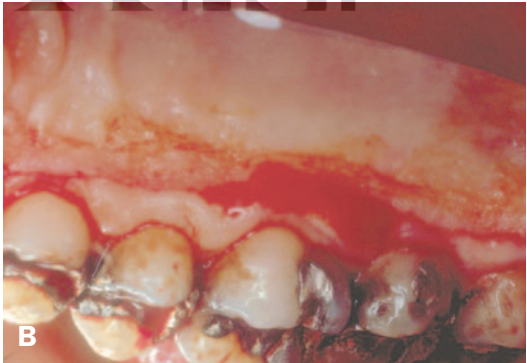
F



F'

FIGURE 7-8. *Continued.* D and D', The primary and secondary incisions are completed. The primary incision is carried down to the bone, making sure that the periosteum is severed at the base of the inner flap. The secondary incision is a sulcular incision made down to the crest of bone. E and E', Ochsenbein chisels are used to remove the secondary inner flap and expose bone. F and F', The flaps are sutured apically and the interproximal areas are permitted to granulate in by secondary intention.

FIGURE 7-9. Modified partial-thickness flap (ledge-and-wedge technique). A, Before. B, Gingivectomy incision completed. C, Excised gingival tissue removed. D, Primary flap reflected. E, Secondary (2°) inner flap being removed. F, Secondary flap removed and osseous contouring completed. G, Flap sutured.



- incomplete thinning of the tissue. The margin of the flap stands away from the tooth when the flap is replaced (Figure 7-11B). This can be corrected by additional thinning of the inner flap surface close to the base of the original incision or by more osteoplasty.
3. Incision beyond the vertical height of the

- alveolus, bringing the scalpel blade in close proximity to the palatal artery (Figure 7-11C). Cutting the palatal artery can be especially dangerous near its exit point from the greater palatine foramen.
4. Extensive beveling or thinning of tissue on a low, broad palate invites damage to the palatal artery (Figure 7-11D).

5. Tissue placement high onto the teeth results in poor adaptation and recurrent pocket formation. This can be corrected by proper trimming at the time of flap placement prior to suturing (Figure 7-11E); this is usually accomplished with scissors or scalpel blade. It often results in a thick, heavy margin.

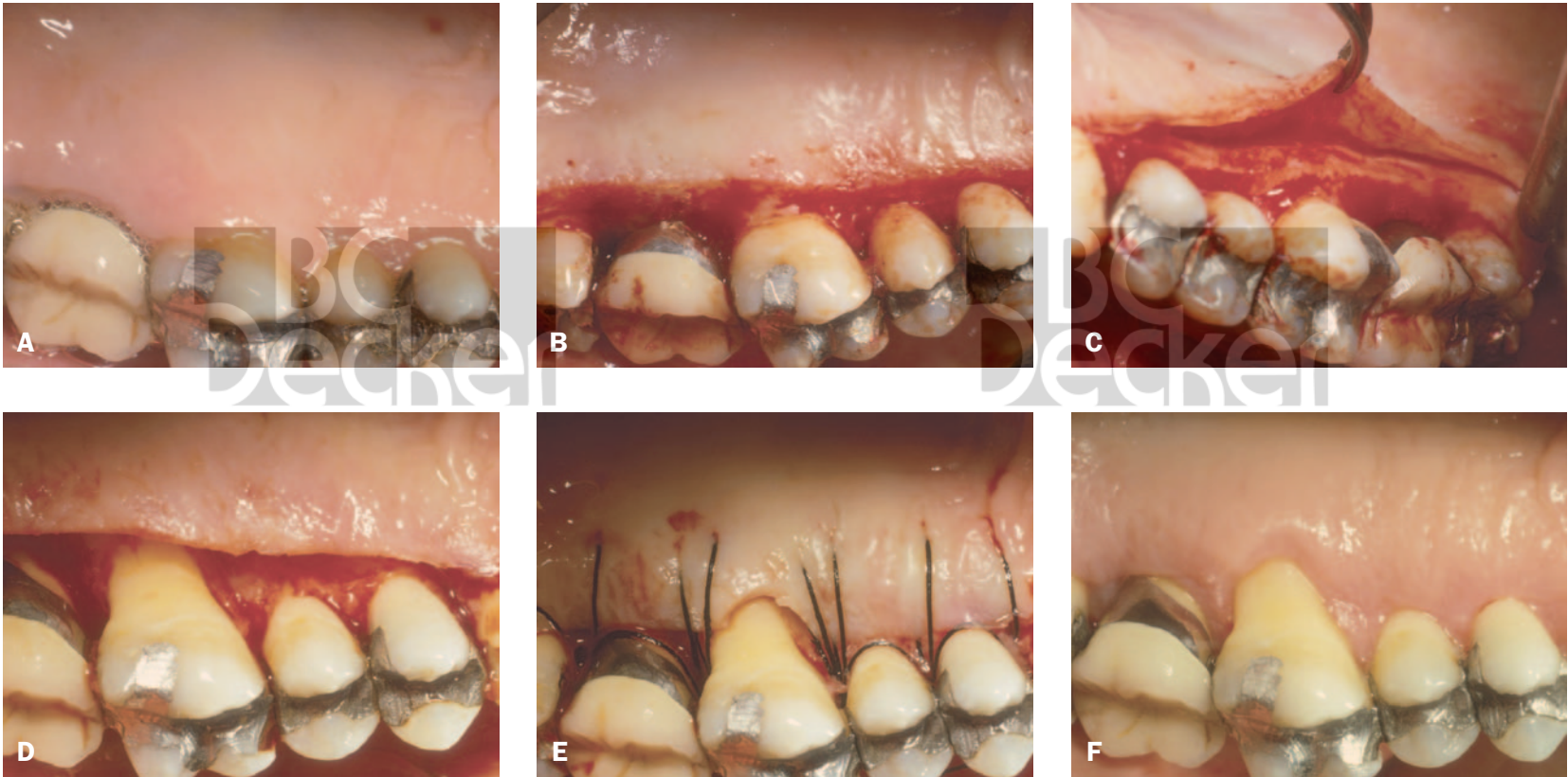


FIGURE 7-10. Modified partial-thickness flap. A, Before. B, Excised gingivectomy tissue. C, Primary partial-thickness flap reflected. D, Secondary inner flap removed. E, Palatal flap sutured. F, Five months later.

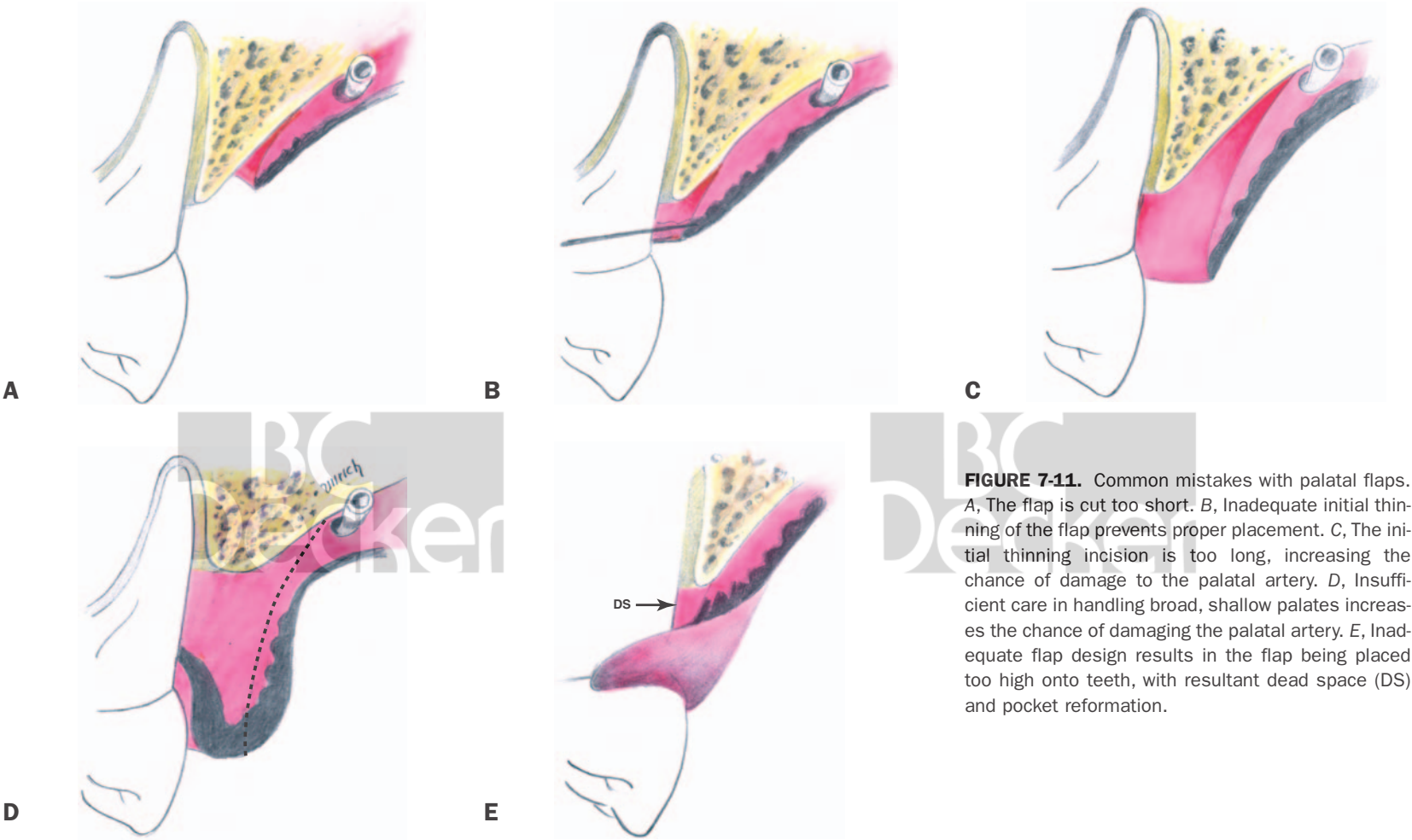


FIGURE 7-11. Common mistakes with palatal flaps. A, The flap is cut too short. B, Inadequate initial thinning of the flap prevents proper placement. C, The initial thinning incision is too long, increasing the chance of damage to the palatal artery. D, Insufficient care in handling broad, shallow palates increases the chance of damaging the palatal artery. E, Inadequate flap design results in the flap being placed too high onto teeth, with resultant dead space (DS) and pocket reformation.

Distal Wedge

The retromolar area of the mandible and the tuberosity of the maxilla offer unique problems for the clinician. These generally have enlarged tissue, unusual underlying osseous topography, and, in the case of the retromolar area, a fatty, glandular, mucosa-type tissue. Historically, while periodontal surgical techniques were being developed for all other areas, development in this one area remained stagnant, and gingivectomy was the treatment of choice. This problem was first addressed by Robinson in 1963 and later by Kramer and Schwartz (1964), but it was Robinson's classic article on the distal wedge operation (1966) that outlined the indications and treatment procedures still used today.

The distal wedge operation overcame the shortcomings of the gingivectomy procedure, which did not allow treatment of irregular osseous deformities or access to the maxillary distal furcation area.

Advantages

1. Maintenance of attached tissue
2. Access for treatment of both the distal furcation and underlying osseous irregularities
3. Closure by a mature thin tissue, which is especially important in the retromolar area
4. Greater opening and access when done in conjunction with other flap procedures. The main limitation is only one of access or

anatomy (eg, ascending ramus or external oblique ridge).

Wedge Designs

1. Triangular
2. Square, parallel, or H design
3. Linear or pedicle

The size, shape, thickness, and access of the tuberosity or retromolar area determine treatment procedures.

Triangular Design. This requires an adequate zone of keratinized tissue and can be used in a very short or small tuberosity.

A triangular incision is made distal to the last molar using a no. 12 or no. 15 scalpel blade (Figure 7-12A). Using scalers, hoes, or knives, the triangular wedge of tissue is removed (Figure 7-12B). The walls of the wedge are thinned or undermined, using scalpel blades to allow proper adaptation to the underlying bone. In Figure 7-12, C and D, we see the outline of the incisions, removal of the secondary wedges, and reflection of the flap for bone exposure. Periosteal elevators are used to reflect the flap. It is sometimes necessary to use small releasing incisions at the apex of the incision to relieve tension (see Figure 7-12A [a, b]). Once the osseous corrective procedures have been completed and the teeth scaled, root planed, and flushed of debris, primary closure is done by interrupted sutures (Figure 7-12, E and F).

A small area adjacent to the tooth usually is not completely closed and heals by secondary intention.

Square, Parallel, or H Design. This technique allows conservation of keratinized tissue and maximum closure. It also provides greater access to the underlying bony topography and the distal furcation. It is indicated where the tuberosity is longer.

Using a no. 15 blade, two parallel inverse-beveled thinning incisions are made. They begin at the distal end of the edentulous area and are continued to the tooth (Figure 7-13, A and B). Two more incisions are made to free the flaps, one in the sulcus adjacent to the tooth and the other at the terminal end of the operative field (see Figure 7-13A). The blade is directed toward the buccal and palatal aspects of the edentulous ridge as the incisions are made.

Periosteal elevators are used to raise the flaps buccally and lingually or palatally. Kirkland or Orban knives may be used to remove the wedge of tissue down to the bone (Figure 7-13, C and D). After the bone is exposed and the necessary osseous surgery and scaling and root planing have been completed (Figure 7-13E), interrupted sutures are used for closure (Figure 7-13F).

The retromolar area often has minimal keratinized tissue, and the tissue is often mucosal glandular tissue, for which gingivectomy cannot be used. The wedge is the only possible way to thin and reduce the tissue in this area.

The procedures are outlined clinically in Figures 7-14 to 7-16.

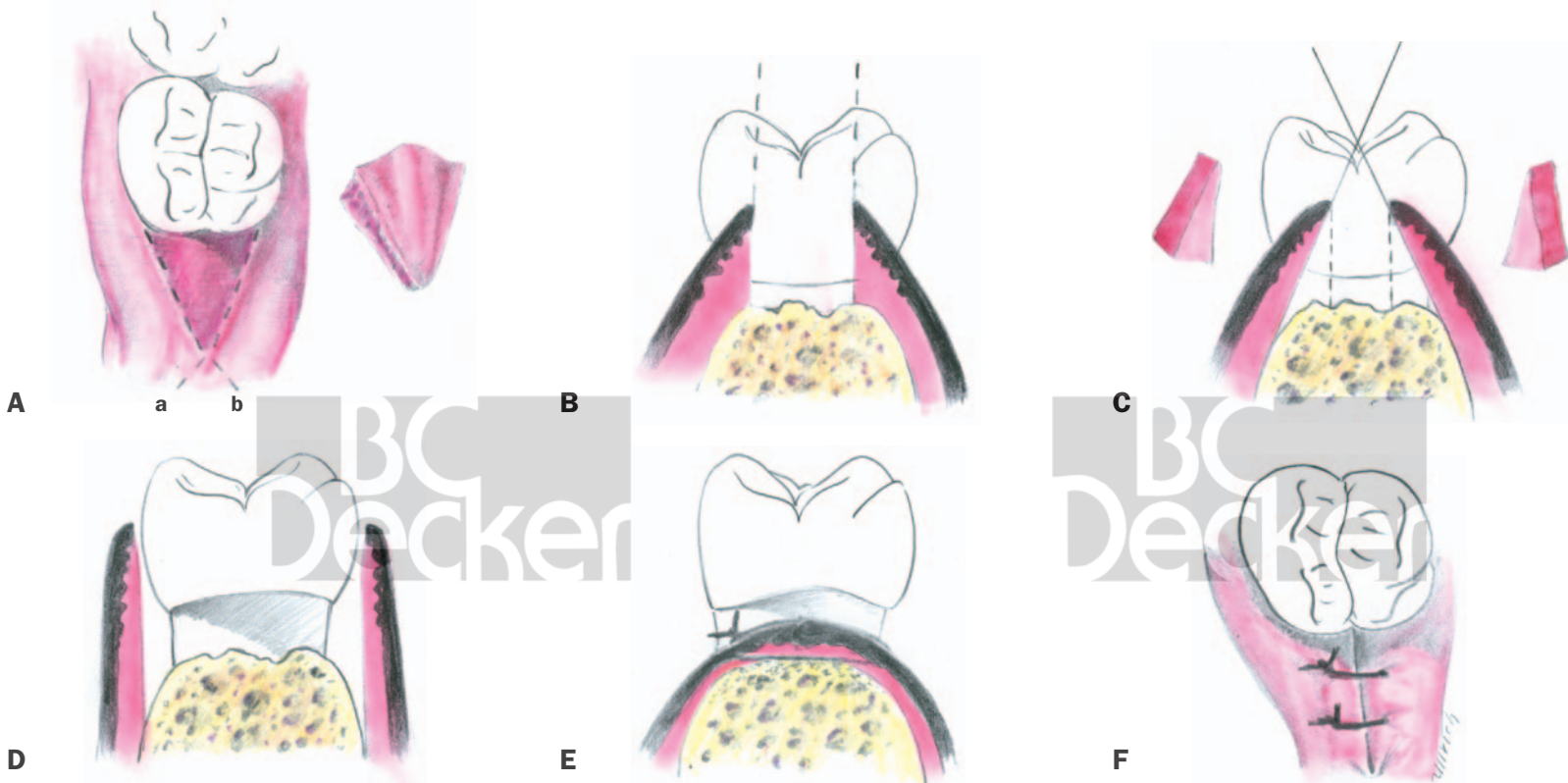


FIGURE 7-12. Distal wedge—triangular design. A, Outline of triangular incision distal to the molar. Note the outline of two small releasing incisions (a, b), which can be used if needed. B, Cross-sectional view showing wedge removal and thick tissue. C, Undermining incisions are used to thin the tissue. D, Reflection of flaps for osseous correction. E and F, Cross-sectional and occlusal views of sutured tissue.



FIGURE 7-13. Distal-wedge—square, parallel, or H design. A, Occlusal view with incisions outlined. Note two parallel incisions over tuberosity joined by distal releasing incision (a, b). B, Cross-sectional view shows proper blade angulation in making initial incisions. C and D, Flaps reflected and tissue being removed from tuberosity using a periodontal knife. E, Bone exposed for correction of osseous irregularities. F, Final suturing.

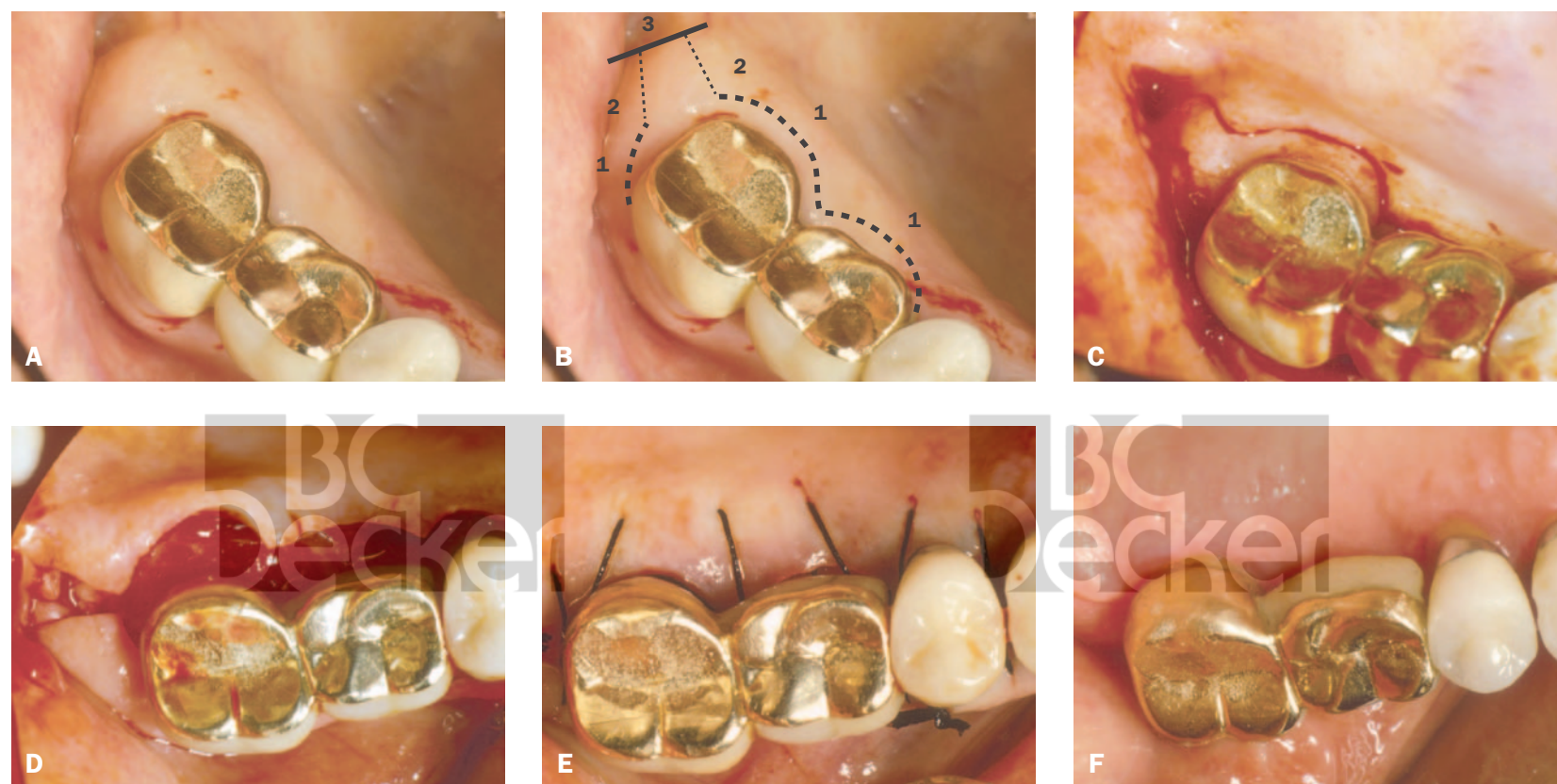


FIGURE 7-14. Distal wedge of maxillary tuberosity area. A, Before. B, Outline of incisions: 1, scalloped, inverse-beveled incision; 2, wedge-shaped parallel incisions; and 3, perpendicular incision at terminal ends of parallel incisions. C, Initial incision completed. D, Secondary flap removed and flap reflected. E, Flaps sutured. F, Case completed 3 months later; compare with A.

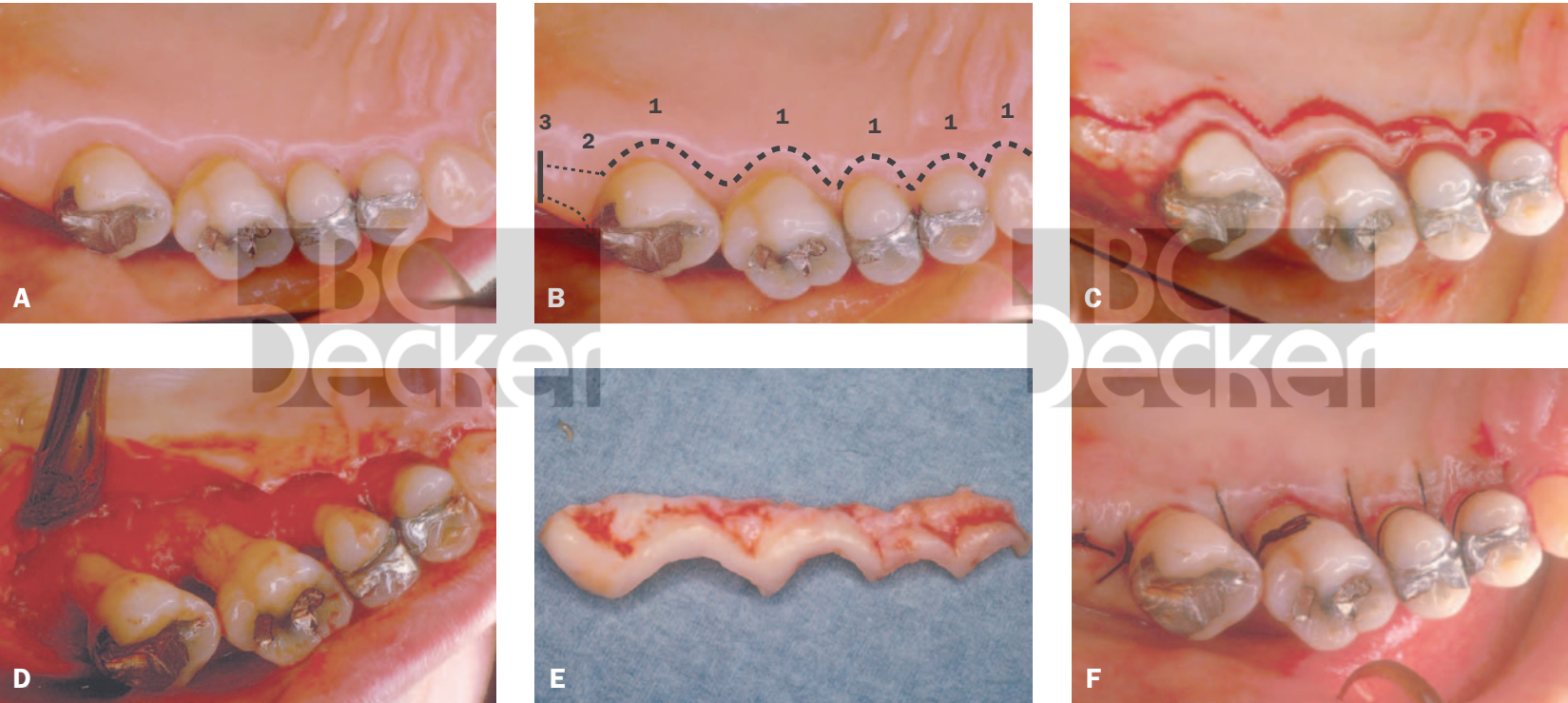


FIGURE 7-15. Distal wedge and partial-thickness palatal flap procedures combined. *A*, Before. *B*, Incisions outlined: 1, scalloped partial-thickness primary incision; 2, parallel wedge incisions; and 3, perpendicular wedge incision. *C*, Initial incisions completed. *D*, Secondary flaps removed and flaps reflected. *E*, Wedge removed. *F*, Flaps sutured. Note primary closure of distal wedge areas.

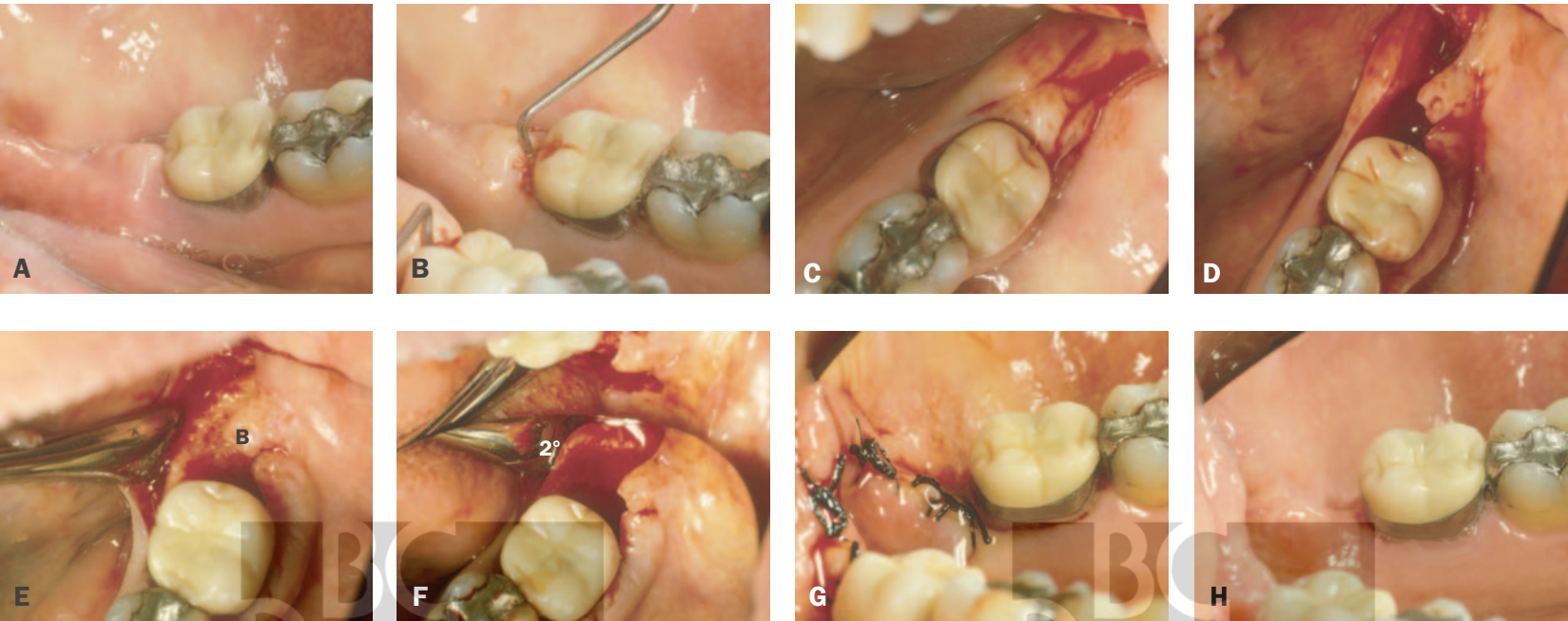


FIGURE 7-16. Distal wedge of the retromolar area of the mandible. *A*, Before. *B*, Probe showing 12 mm pocket. *C*, Parallel incisions made and joined distally later with perpendicular incision. *D*, Wedge removed. *E*, Lingual flap thinned by secondary incision (2° flap). *F*, 2° flap removed and bone exposed. *G*, Wedge sutured. *H*, Wedge healed, 3 months later.

Palatal Approach to Implant Placement

To avoid the difficult healing with vestibular incisions and at the same time provide adequate implant coverage, especially when augmentation procedures are required, Langer and Langer (1990) recommended a palatal approach.

Advantages

1. The use of overlapping flaps prevents flap opening and implant exposure
2. Facilitates healing and reduces postoperative trauma

Procedure

1. A horizontal incision is made 5 to 6 mm apical to the crest of the ridge with a no. 15 blade (Figure 7-17A).
2. The horizontal incision is extended apically with a no. 1 blade held parallel to the vertical height of the palate. A partial-thickness flap is raised (Figure 7-17B).

Note: All incisions are kept on the vertical height of the alveolus to avoid damaging the palatal artery.

3. The blade is now used to score the periosteum apically for flap release.
4. Internal vertical releasing incisions are made at the terminal end of the horizontal inci-

sions, which are carried onto the buccal surface. The outer epithelial portion of the flap need not be incised.

5. Oschenbein chisels or large hoes are now employed for reflection of the inner flap (Figure 7-17C).
6. The implant(s) is placed (Figure 7-17D).
7. The flap is repositioned (Figure 7-17E).
8. Vertical and/or horizontal mattress sutures are used for flap closure and stabilization. Mattress sutures will minimize clot formation by pulling the flaps tightly against the bone and to each other (Figure 7-17F).

The clinical procedure is depicted in Figure 7-18.

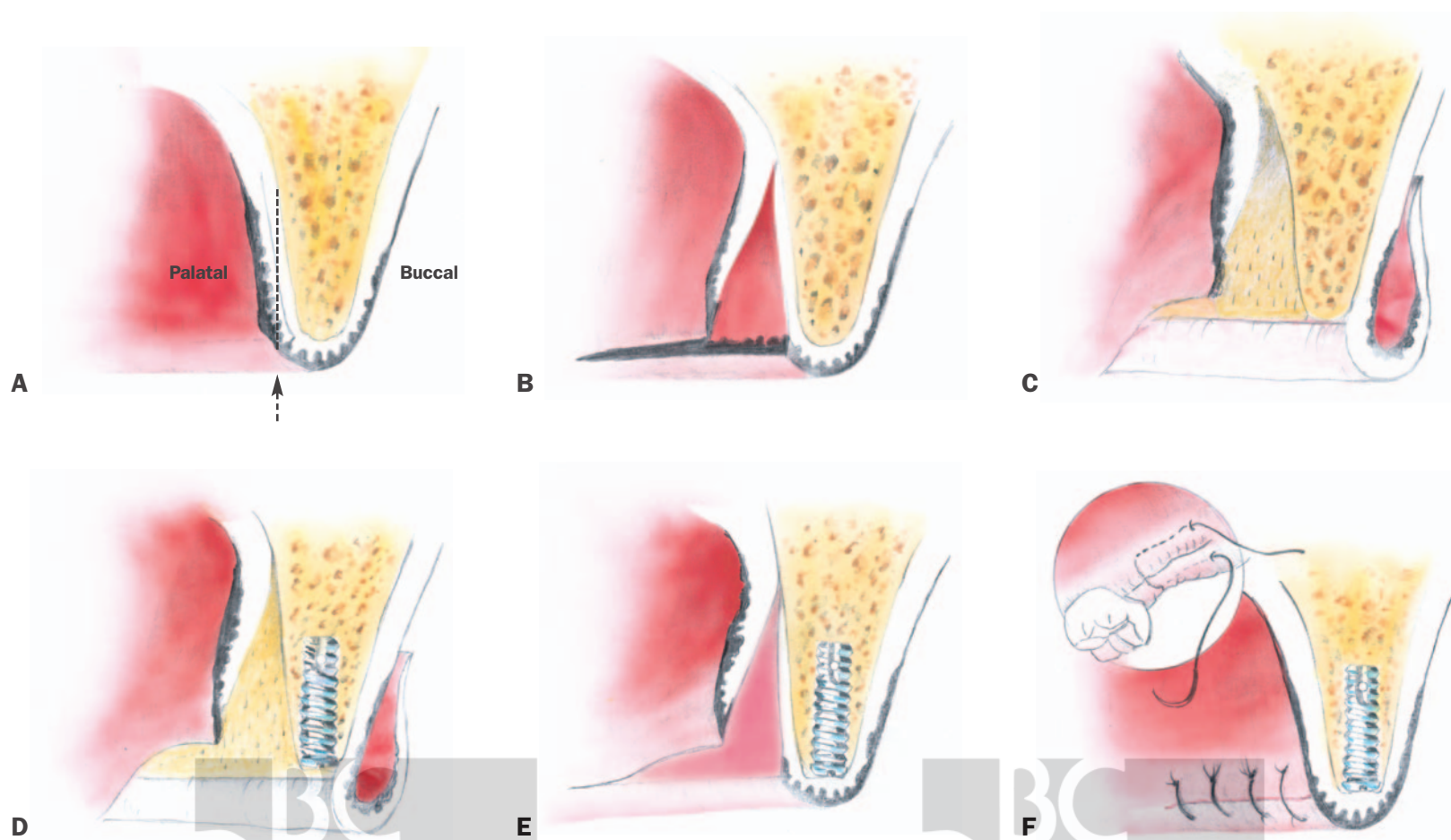


FIGURE 7-17. Palatal approach for implant placement. *A*, Cross section of maxillary alveolar ridge with incision on the palate. *B*, Partial-thickness palatal flap raised (see Figure 7-5 for technique). *C*, Inner secondary flap reflected buccally, exposing the osseous ridge. *D*, Implant placed. *E*, Secondary inner flap replaced. *F*, Primary and secondary flaps sutured with vertical or horizontal mattress sutures. Note that even if the coronal aspects of incision were to open, the apical overlap would maintain primary closure.

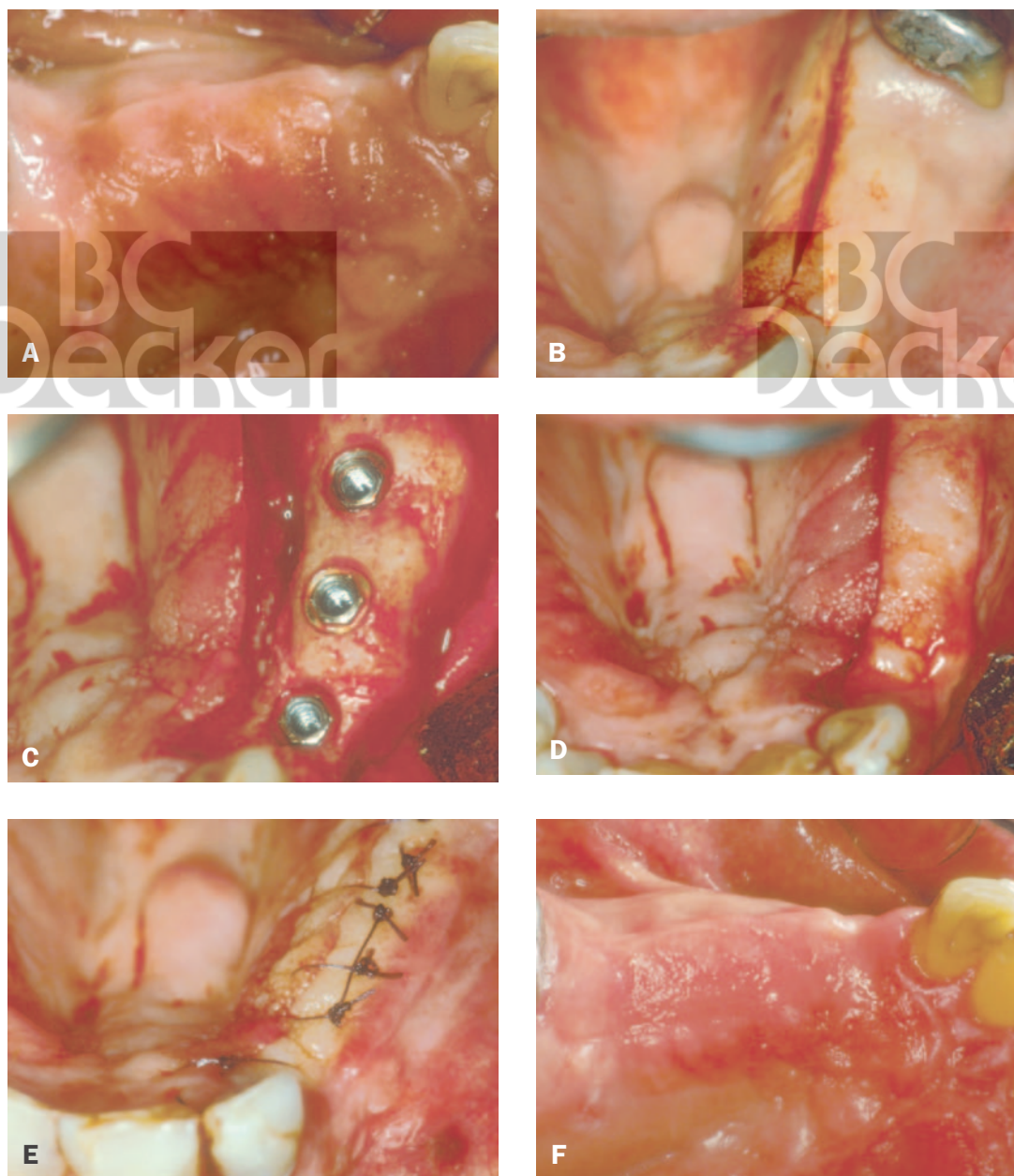


FIGURE 7-18. Palatal approach for implant placement. *A*, Before surgery. *B*, Partial-thickness palatal flap begun; initial incision. *C*, Implant placement completed. *D*, Flap reapproximated; note excellent primary closure. *E*, Vertical mattress sutures for closure. *F*, Three months later.

Cosmetic Treatment of Maxillary Anterior Pocketing

Modified Surgical Approach for Maxillary Anterior Esthetics: Curtain Procedure

One of the most distressing aspects of periodontal surgery is the unesthetic maxillary anterior results obtained after definitive surgical pocket elimination therapy. The elongation of the crowns with greater root exposure and an increase in interproximal spacing results in a totally unacceptable *picket-fence* appearance, with varying degrees of speech difficulty.

In 1967, Frisch and colleagues developed a surgical technique that permitted conservation of the maxillary anterior esthetics. This modified surgical approach, or *curtain procedure*, which is somewhat similar to Kirkland's (1931, 1936) *semiflap* and *modified flap* techniques, attempt to satisfy the esthetic and phonetic considerations of surgical procedures in this area.

This technique attempts to preserve all labial attached gingiva, even the labial third of the interproximal papillae. It was based on their finding that even in the presence of interproximal disease, a healthy midlabial sulcus can exist with healthy labial tissue. Lie (1992) recently described the advantages and methodology of this procedure, which he termed the modified resective technique.

Advantages

1. Conservative
2. Esthetically acceptable
3. Technically simple and easy to do
4. Maintains phonetics, with normal speech

Disadvantages

1. Some labial shrinkage is unavoidable.
2. Oral physiotherapy is more difficult because of tissue craters.

Criteria for Treatment

Frisch and colleagues listed several preoperative conditions, of which the most important is that the gingival tissue appears to be clinically healthy (firm, pink, and stippled), with a midlabial sulcus depth ≤ 4 mm, even when deep interproximal pockets are present.

This technique appears to satisfy all of the necessary criteria for treating the maxillary anterior teeth if esthetics are a problem. Long-term success is achieved by ease of access and maintainability of the area for oral hygiene. The round roots allow effective flossing, and palatal access to the longer roots is easy.

Procedure

1. Figure 8-1A displays the common finding of clinically healthy gingival tissue with significant underlying osseous destruction. This

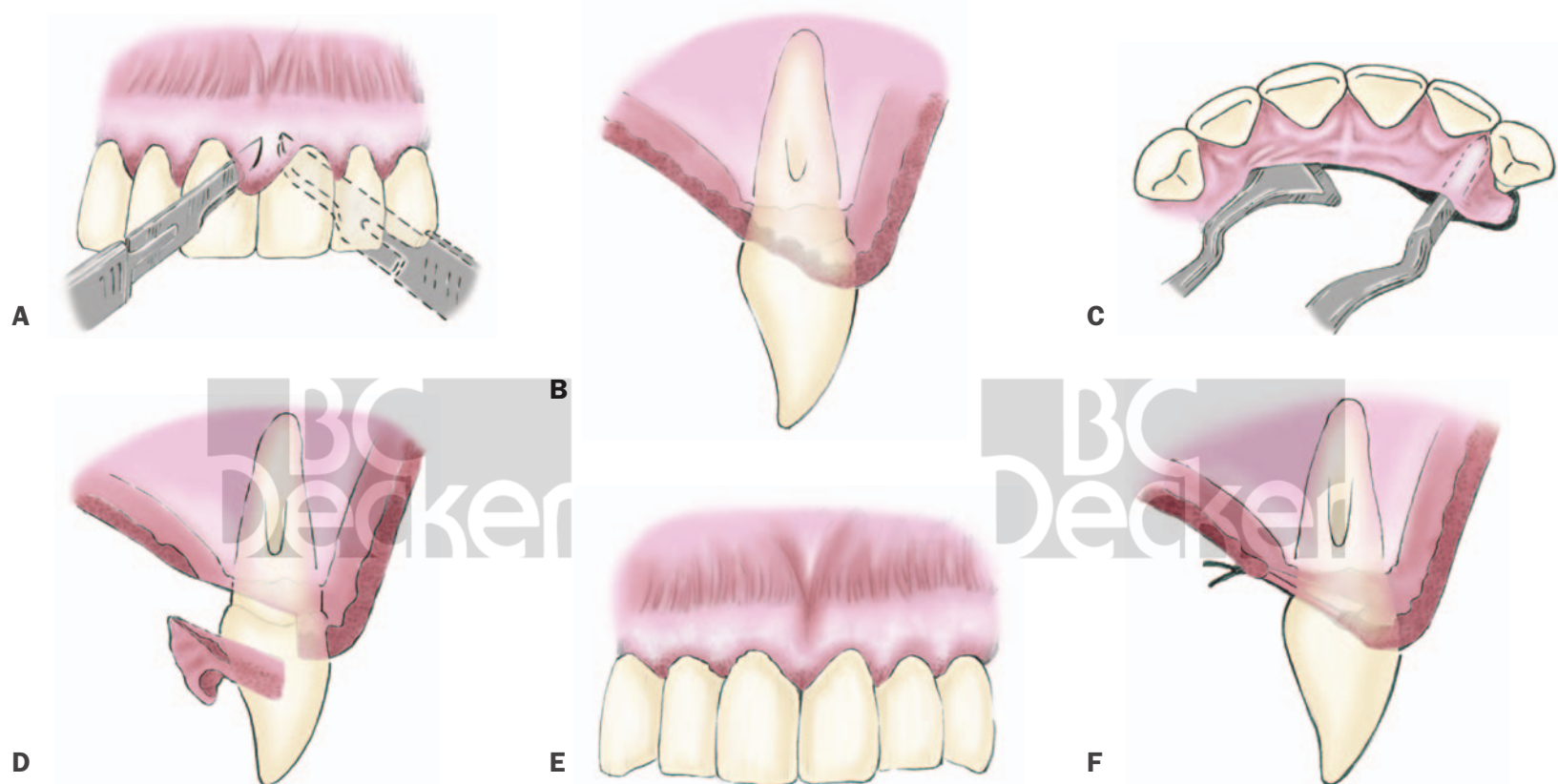


FIGURE 8-1. Curtain procedure. A and B, Before surgery. C and D, Palatal gingivectomy with side view showing removal of tissue. E and F, Buccal and side views showing suturing with no esthetic compromise. **Note:** Palatal bone exposure is shown in Figure 7-2.

problem is further compounded by a high smile line.

2. Figure 8-1B shows the basic outline of the incision. The incisions are designed for maximum conservation of the facial gingiva and at least one-third of each of the labial papillae. Palatally, either a beveled gingivectomy or a partial-thickness palatal flap procedure can be performed.
3. The initial incisions are made with a no. 11 or no. 15 scalpel blade. The blade is directed interproximally at right angles to the teeth from both the mesial and distal directions (Figure 8-1C). This intersecting incision separates the labial one-third of the papilla, which, combined with the labial tissue, forms the *tissue curtain*. No further labial surgery is required.
4. Palatally, the objectives and need for osseous surgery determine whether a gingivectomy or flap procedure is used (Figure 8-1D). Even though gingivectomy is faster and simpler, if the bony craters can be ramped palatally, plaque control will be facilitated.
5. Figure 8-1, E and F, show the final suturing, which can be interrupted or continuous.

In Figure 8-2, we see the same procedure except that a palatal flap was raised for treatment of underlying osseous depravities. In this technique, the buccal two-thirds of the interproximal papillae are still retained to prevent shrinkage, and there is *no need* to release or reflect the papilla from the buccal surface.

The clinical examples that follow (Figures 8-3 and 8-4) show the favorable results that can be achieved with this technique. Note carefully the minimal amount of labial recession even though significant recession occurs palatally.

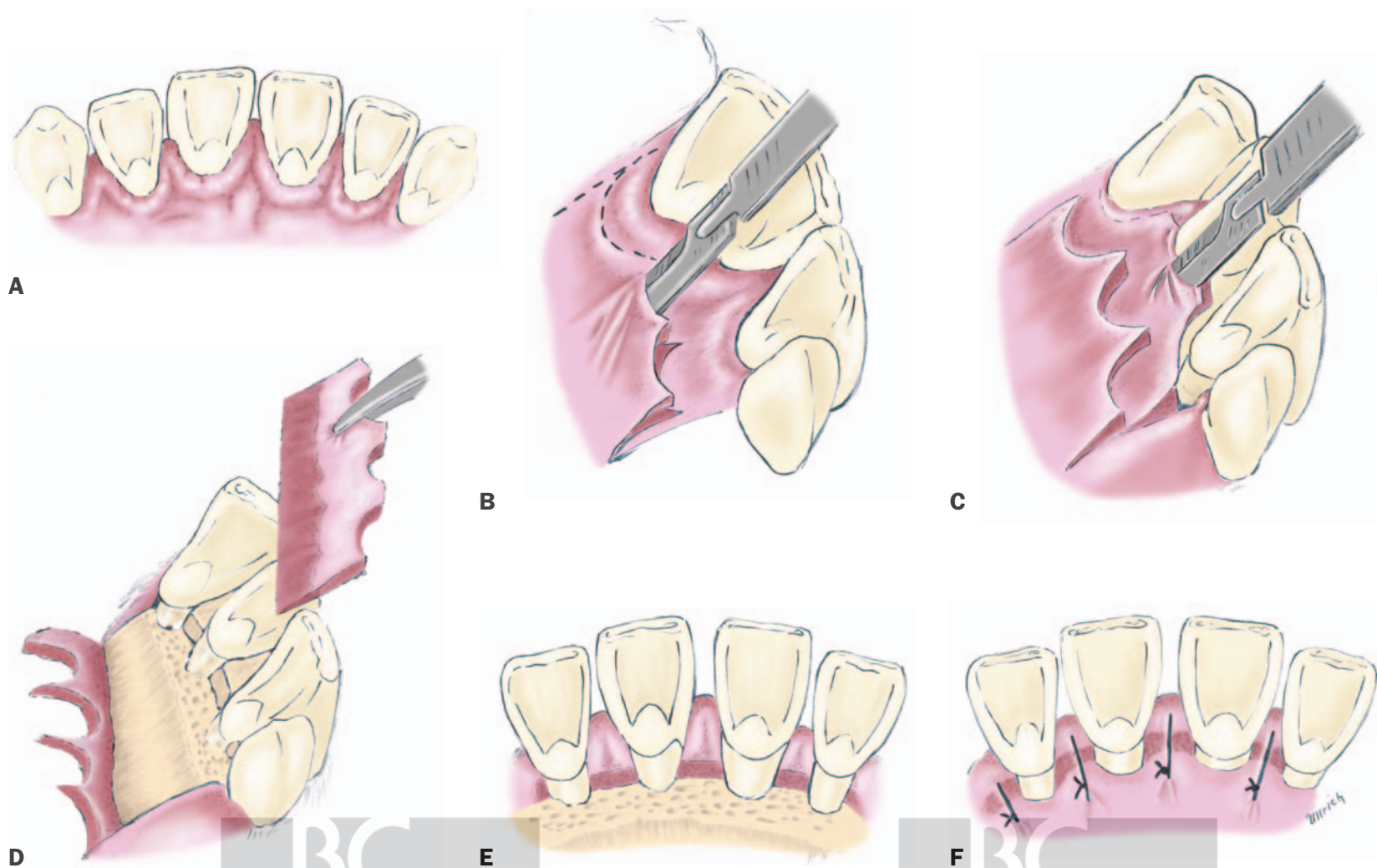


FIGURE 8-2. Curtain procedure combined with a palatal flap. *A*, Palatal view of anterior teeth with deep interproximal pockets. *B*, Scalloped palatal partial-thickness flap (see Chapter 6, “Mucogingival Surgery,” for the technique). *C*, Secondary inner flap is released with palatal sulcular incisions and extended interproximally from the palatal side only one-third of the distance interproximally. **Note: No buccal release is required.** *D*, The inner flap is reflected and removed. *E*, Scaling, root planing, and corrective osseous surgery are performed (inductive or receptive). *F*, Flaps are positioned and sutured.



FIGURE 8-3. Curtain procedure. A and B, Before; buccal and palatal views. C, Preoperative radiograph studies show moderate bone loss. D and E, Sulcular interdental incisions maximize the buccal two-thirds of the papillae. F, Scalloped palatal incision for flap preparation. G, Flap reflected and secondary inner flap removed. H, Osseous surgery completed. I and J, Buccal and occlusal view of flaps sutured with interrupted sutures. K and L, After 4 months. Note minimal reduction of buccal tissue and esthetic result.



FIGURE 8-4. Curtain procedure. A and B, Before; buccal and palatal views. C, Sulcular interdental incisions maximizing the buccal two-thirds of the papillae. D, Palatal flap completed. E and F, Buccal and palatal flaps sutured. G and H, Completed case 5 months later.

Papillary Preservation Technique

Takei and colleagues (1985, 1988, 1991) devised a surgical procedure to prevent partial or complete exfoliation of graft material by providing prima-

ry coverage of the entire interproximal defect. The authors acknowledged that it is a modification of a procedure originally described by Genon and Bender (1984) for esthetic treatment of the maxillary anteriors.

Indication

- 1. Embrasures wide enough to permit passage of the interproximal tissue

Advantages

1. Esthetically pleasing
2. Primary coverage of implant material
3. Prevention of postoperative tissue craters

Disadvantages

1. Technically difficult
2. Time consuming

Contraindication

1. Narrow embrasures

Procedure

1. Buccally, interproximally, and palatally/lingually, the flaps are relieved with intrasulcular incisions, keeping the blade adjacent to the tooth.
2. Vertical incisions are made palatally/lingually adjacent to the papillae that are to be moved. The vertical incisions are extended far

enough apically so that they will be at least 3 mm apical to the margin of the interproximal bony defect and 5 mm from the gingival margin (Figure 8-5, A and B).

3. The vertical incisions are joined by a horizontal incision, which can be made with a Kirkland knife (see Figure 8-5B).
4. For flap reflection, a curet or interproximal knife is used to free the interdental tissue from the underlying tissue. **Note: The papilla must be completely mobile prior to reflection (Figure 8-5C).**
5. With a blunt instrument, the papilla is carefully pushed through the embrasure, and

excessive granulation is removed from the underside with a sharp scissors or curet. Overthinning is to be avoided (Figure 8-5D).

6. Both the flap and the papilla are reflected off the bone with a periosteal elevator (Figure 8-5E).
7. Once the defect area is débrided and filled, the flaps are repositioned and the papilla is pushed back through the embrasure and sutured with interrupted or horizontal mattress sutures (Figure 8-5F).

The clinical procedure is seen in Figures 8-6 and 8-7.

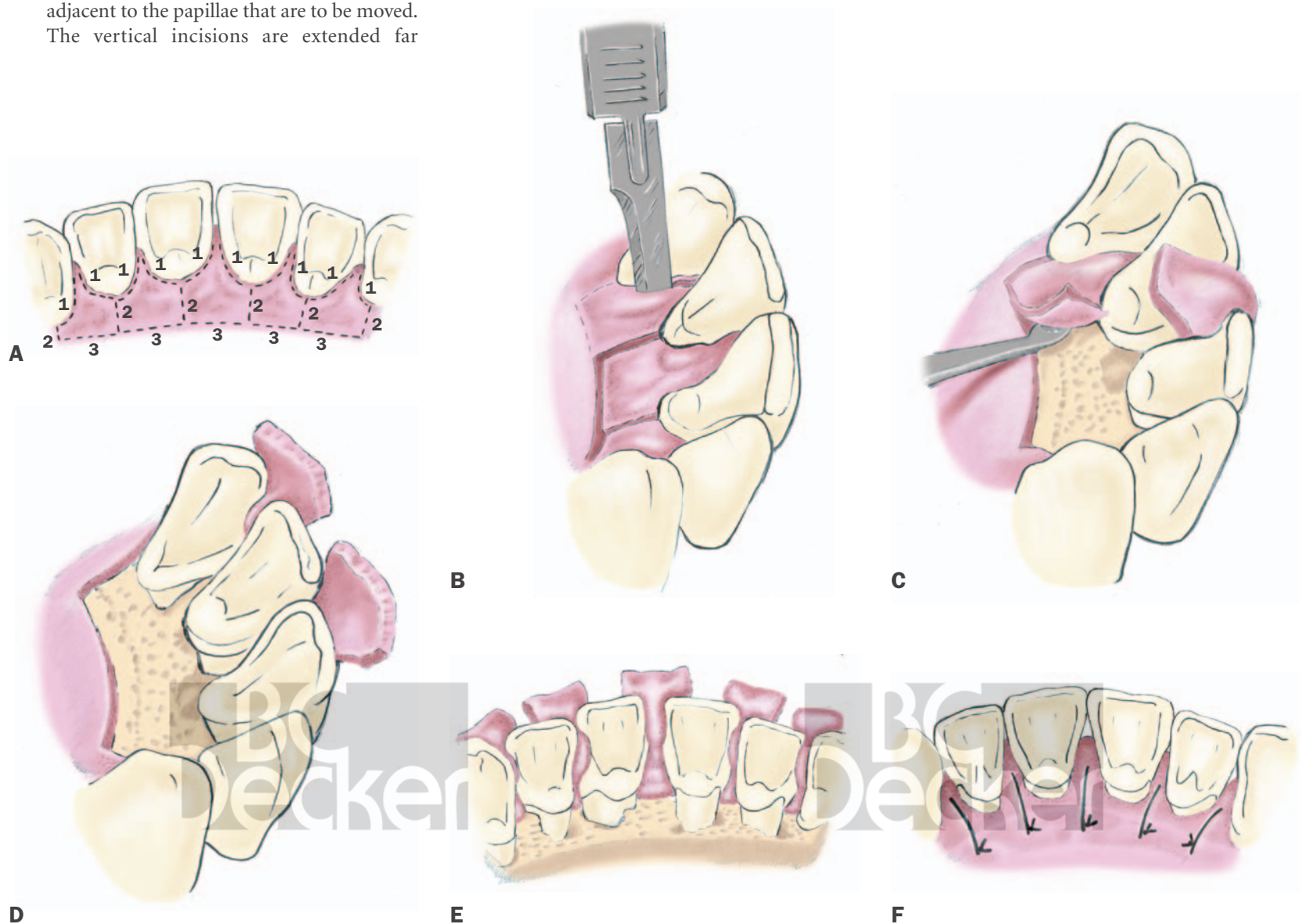


FIGURE 8-5. Papillary preservation technique. A, Palatal view with incisions outlined. B, Completion of palatal incisions. C, A periosteal elevator is used to reflect individual papillary flaps. D, A blunt instrument used to push tissue buccally, exposing underlying osseous deformities and subgingival root deposits. E, Defects débrided, root scaled, and root planed. F, Flaps sutured palatally. Suturing should avoid papillary compression, which may result in loss of interproximal tissue height.



FIGURE 8-6. Papillary preservation technique. *A* and *B*, Buccal and palatal views with incisions outlined before treatment. *C*, Initial horizontal and vertical incisions completed. Note vertical and horizontal incisions to facilitate flap elevation. *D*, Flap reflected buccally. *E*, Buccal view with papillary flaps reflected buccally. *F*, Palatal flap reflected prior to scaling. *G* and *H*, Buccal and palatal views of flaps sutured. Note minimum conservation of interproximal tissue. Compare with *A*. *I* and *J*, Eight months later; buccal and palatal views. Note excellent cosmetics even though the palate shows considerable recession. Compare with *A* and *B*.



FIGURE 8-7. Papillary preservation technique. *A* and *B*, Before treatment; buccal and palatal views with incisions outlined. *C* and *D*, Buccal and palatal views at the time of the initial incisions. Note primary gingivectomy incisions. *E*, Palatal papillary flap reflected buccally. *F*, Palatal flap reflected. *G* and *H*, Buccal and palatal views at the time of suturing. *I*, Two months later; palatal view. Note the uneven gingival margin. *J*, Gingivoplasty for tissue removal of uneven tissue. *K*, Three months later; excellent cosmetic result. *L*, One month after gingivoplasty.



Resective Osseous Surgery

Historical Review

Historically, osseous surgery was performed for the primary purpose of eliminating necrotic or infected bone. This was the generally held belief until Kronfeld (1935) established that all bone is healthy. This led to the modern concepts of osseous resective and inductive surgery, which are based primarily on the work of the following individuals:

1. Goldman (1950), "The Development of Physiologic Gingival Contours by Gingivoplasty"
2. Schluger (1949), "Osseous Resection—A Basic Principle in Periodontal Surgery"
3. Friedman (1955), "Periodontal Osseous Surgery: Osteoplasty and Osteotomy"
4. Prichard (1957), "The Infrabony Technique as a Predictable Procedure"

5. Goldman and Cohen (1958), "The Infrabony Pocket: Classification and Treatment"
6. Ochsenbein (1958), "Osseous Resection in Periodontal Surgery"
7. Ochsenbein (1986), "A Primer for Osseous Surgery"

Their work established the basic guidelines, definitions, terminology, and treatment procedures used today.

Rationale and Objectives

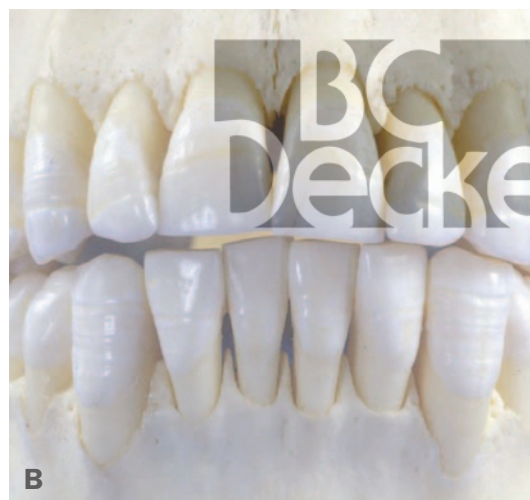
The basis for performing resective osseous surgery lies in the fact that periodontal disease attacks the underlying or supportive bony architecture. This resorptive process results in an osseous form with sharp, uneven marginal deformities and irregularities. The bone, being

hard, maintains these irregularities, whereas the gingival tissue, being soft, tends to follow a more fluid form. These inherent differences result in deep pockets that can be probed.

Osseous resective surgery has as its primary objectives the removal of osseous deformities and the creation of a physiologic parabolic contour: a physiologic osseous form that will mimic the final anticipated gingival architecture. This contour will be conducive for pocket elimination and maintenance of physiologic gingival architecture. The interdental area will be conical and coronally positioned to the buccal and lingual (palatal) plates of bone, which have a parabolic shape and flow smoothly from the interdental area (Figure 9-1). The interdental area will follow the shape of the cemento-enamel junction and have a prominent conical shape anteriorly that tends to become flatter and broader in the molar areas



FIGURE 9-1. Ideal gingival and osseous contours. A and B, Gingival contours anteriorly and posteriorly showing a scalloped, parabolic architecture with a pyramid-shaped conical papilla. A' and B', Underlying osseous architecture with scalloped parabolic contours that mimic gingival form. Note the decrease in the degree of gingival and osseous scallop from anterior to posterior.



(Figure 9-2). These factors allow a thin, scalloped, knife-edged gingival architecture with pyramid-shaped papillae that fill the interproximal space.

It is important to note that Ochsenbein (1977) pointed out that the gingival tissues were the dominating factor in establishing the osseous contours. He believed that after surgery the gingival tissues would tend to seek their original architectural form.

Osseous Classification

Osseous surgery may be

1. Additive: regeneration or substitution of bone (see Chapters 10, “Inductive Osseous Surgery” and 11, “Guided Tissue Regeneration”).
2. Subtractive: resection or removal of bone
 - a. Definitive: establishes a positive or normal parabolic osseous form
 - b. Compromised: indicates an osseous topography requiring extensive osseous removal that would be detrimental to the long-term prognosis of the tooth

Osseous Topography

Osseous form is classified based on the interrelationship of the interdental (or interradicular) bone to the radicular bone.

1. Positive or scalloped: interdental bone higher than the radicular or facial bone
2. Flat: interdental bone and radicular bone are at the same level
3. Negative or reversed: interdental bone is apical to the radicular bone

Note: The bone in the furcation is most often considered to be similar to the interdental bone for the purposes of classification.

Osseous resective surgery is the most predictable and maintainable pocket reduction tech-

nique, and it is the only technique that significantly reduces the destructive bacterial colonies (Mombellil and colleagues, 1995; Rawlinson and colleagues, 1995; Levy and colleagues, 1999, 2004a, 2004b; Tuan and colleagues, 2000). Chevy and colleagues (2002) state that “the reduction in pocket depth by surgical means and the associated decrease in reservoirs of periodontal pathogens may be important in achieving sustained periodontal stability....surgery appears to be an important part... to control periodontal infections.”

The World Workshop in Periodontics (1996) listed the following indications for surgical pocket therapy:

1. Root access
 - a. Calculus removal
 - b. Subgingival
 - c. Manage persistent deep pockets
2. Regeneration therapy
3. Corrective osseous surgery
4. Periodontal abscesses
5. Enhance restorative, prosthetic, and cosmetic procedures

Pocket elimination with osseous surgery results in

1. Fewer probing or bleeding sites (Townsend-Olsen 1985; Saxen and colleagues, 1990)
2. The greatest pocket reduction with the least recurrent breakdown (Kaldahl and colleagues, 1996a, 1996b)
3. Alteration of the subgingival microflora from gram-negative anaerobes to gram-positive anaerobes (Gunsolley and colleagues, 1994; Mobelli and colleagues, 1995)

Examination and Treatment Planning

Transgingival probing or sounding (Easley, 1967; Mealey and colleagues, 1997) under anesthesia of the underlying osseous topography is the single

most important aspect of diagnosis. It will allow the clinician to determine

1. Osseous topography
2. Intrabony defects (one, two, or three wall defects)
3. Furcation involvement (Class I, II, or III)
4. Root shape or form

This is critical because flap design for regeneration (maximum conservation of tissue or unrepositioned or repositioned flap) is different from that required for osseous surgery and pocket reduction (thinned tissue or apically positioned flap).

Radiographs are useful in locating areas of bone loss, and whereas some intrabony defects are visualized, many others are not. *Therefore, radiographs should not be used as the primary determining factor when assessing the nature and quality of the osseous topography.*

Tissue Management

Treatment of osseous deformities involves the use of a full-thickness, inverse-beveled, mucoperiosteal flap. The flap is scalloped. As a general rule, *the clinician, when scalloping the flap, should anticipate the final underlying osseous contour, which is most prominent anteriorly and decreases posteriorly* (see Chapter 6, “Mucogingival Surgery”). Partial-thickness flaps are generally not indicated because of the limited access and visibility they provide and the fact that osseous surgery results in a torn, lacerated periosteum with little or no protection for the underlying bone.

All granulation tissue and residual connective tissue fibers must be removed prior to osseous surgery. Small bony defects are often hidden or obscured by residual fibers that are not removed. Plaque, calculus, softened cementum, and remnants of the junctional epithelium are all removed from the root surface.

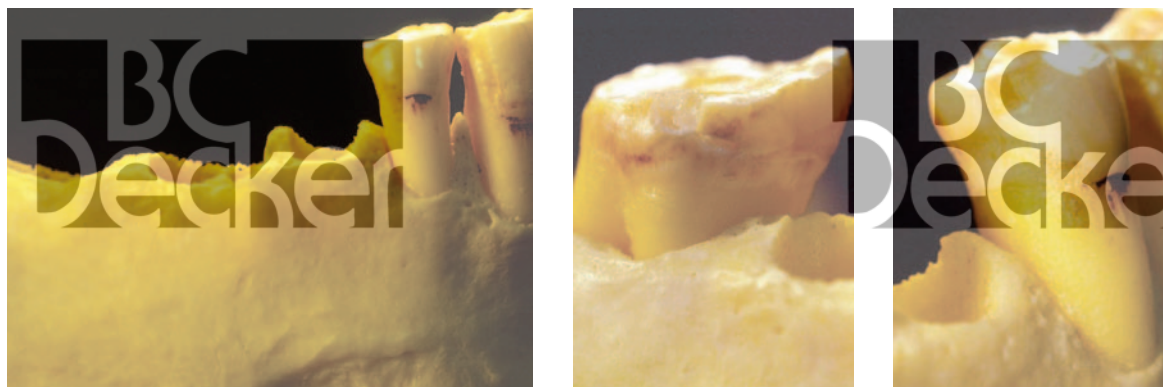


FIGURE 9-2. Interdental osseous form. The interdental osseous form tends to be thinner and more conical anteriorly, becoming flatter and broader in molar areas.

Terminology and Methods

Osseous resective surgery uses the techniques of osteoplasty and ostectomy (Friedman, 1955), which are for the reduction and removal of non-supporting and supporting bone, respectively.

Osteoplasty

Osteoplasty is defined as a plastic procedure by which nonsupporting bone is reshaped to achieve a physiologic gingival and osseous contour for the following purposes (Figure 9-3):

1. Pocket elimination
2. Tori reduction
3. Intrabony defects adjacent to edentulous ridges
4. Incipient furcation involvement
5. Reduction of thick, heavy ledges and/or exostosis
6. Shallow osseous craters

7. Blunted interdental craters
8. Small intrabony defects associated with the buccal or lingual surfaces
9. Enhanced flap placement with improved alveolar contours

Osteoplasty includes the techniques of grooving or festooning (Ochsenbein, 1958) and radicular blending (Carranza, 1984).

Vertical grooving or festooning is designed to reduce the buccal and lingual thicknesses of bone interdentally. These vertical-depth cuts or hollowing out provide greater root prominence on the radicular surface, allowing a more favorable gingival architecture, minimal bone removal, and a smooth transition from the radicular to the inter-radicular space. The vertical grooving often reduces the external walls of small craters, making further osseous contouring unnecessary. For this reason, osteoplasty usually precedes ostectomy.

Radicular blending is generally indicated for use on a thicker, heavier bone, following vertical grooving. The procedure is used to establish an even-flowing, thin radicular surface that rises over root prominences and falls in the valleys established by the vertical grooves.

Blunted Interdental Septa and Thick Bony Margins. Two of the most commonly found early osseous deformities are those of blunted interdental septa and thick or heavy bone margins. They may occur independently but often occur together. They are treated predominantly by osteoplasty.

Procedure. With the flaps reflected, the osseous topography is viewed buccally, lingually (or palatally), and occlusally. This allows the clinician to develop a three-dimensional mental image of the relationships between the individual teeth and their bony housing, which helps determine a perspective for performing osseous surgery.

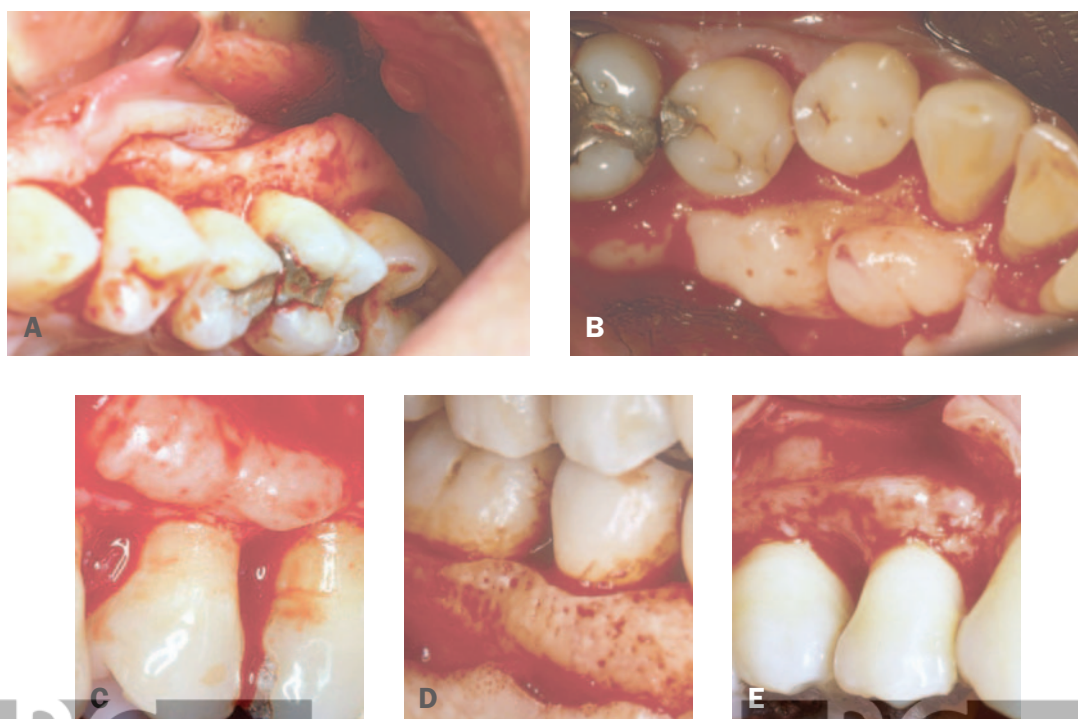


FIGURE 9-3. Indications for osteoplasty. A, Buccal exostosis. B, Lingual tori. C, Blunted interdental septa with thick bony ledges. D, Small crater with heavy ledges. E, Hemisepta with thick heavy ledges.

Figure 9-4A shows blunting of the interdental septa combined with heavy bony margins. The interproximal area, being blunted and without a negative architecture, may require some osseous resective procedures to produce a more definitive positive architecture.

The first step is vertical interradicular grooving or festooning. These grooves are carried to the line angles of adjacent teeth and determine the buccolingual width of the bone. Using a round no. 6, 8, or 10 bur in a high-speed handpiece with copious amounts of water, the grooves are cut (Figure 9-4B).

Once the vertical grooves are completed, radicular blending is begun using the same-size bur (Figure 9-4C). The bur is moved with sweeping strokes as if one were painting, back and forth, rising over the root prominences and falling into the depressions created by the grooves. This is continued until an even-flowing osseous form is created. The round bur sometimes leaves a rough-

ened surface that can be smoothed by using a round diamond stone of similar size.

On completion of radicular blending, a flat crest of bone is left interproximally at the same level as the radicular surfaces. Generally, this is not acceptable because *the gingival tissue will inherently form a scalloped contour with a pyramid-shaped papilla regardless of the underlying bony contours*. The end result, if no further osseous surgery is done, will be a residual tissue pocket of 4 to 5 mm.

To determine the amount of osseous scalloping or ostectomy to be done, it is necessary to know the preoperative shape and form of the tissue because the tissue has a tendency to develop relatively the same shape after surgery. The amount of tissue scalloping necessary will decrease as the interproximal osseous area becomes broader. This is seen as one moves from the incisors to the molars (see Figure 9-2) or as bone loss increases interproximally. *Therefore, as a general rule, the final bony contours should mir-*

ror or approximate the healthy preoperative gingival form. Excessive scalloping or grooving should be avoided.

In Figure 9-4D, a small no. 2 or no. 4 round bur in a high-speed handpiece is used to outline or scribe (see Ostectomy) the bone at the correct level. Care is taken not to contact the teeth. Scribing the bone allows it to be visualized and facilitates removal (with an Ochsenbein no. 1 or 2 chisel) (Figure 9-4E).

The completed osseous form is one with scalloped or parabolic radicular surfaces that gradually rise interdentally to a conically shaped interproximal bone (Figure 9-4F).

Figures 9-5 to 9-7 are clinical examples of this procedure.

Ostectomy

Ostectomy is the plastic removal of radicular and interradicular supporting bone to eliminate osseous deformities.

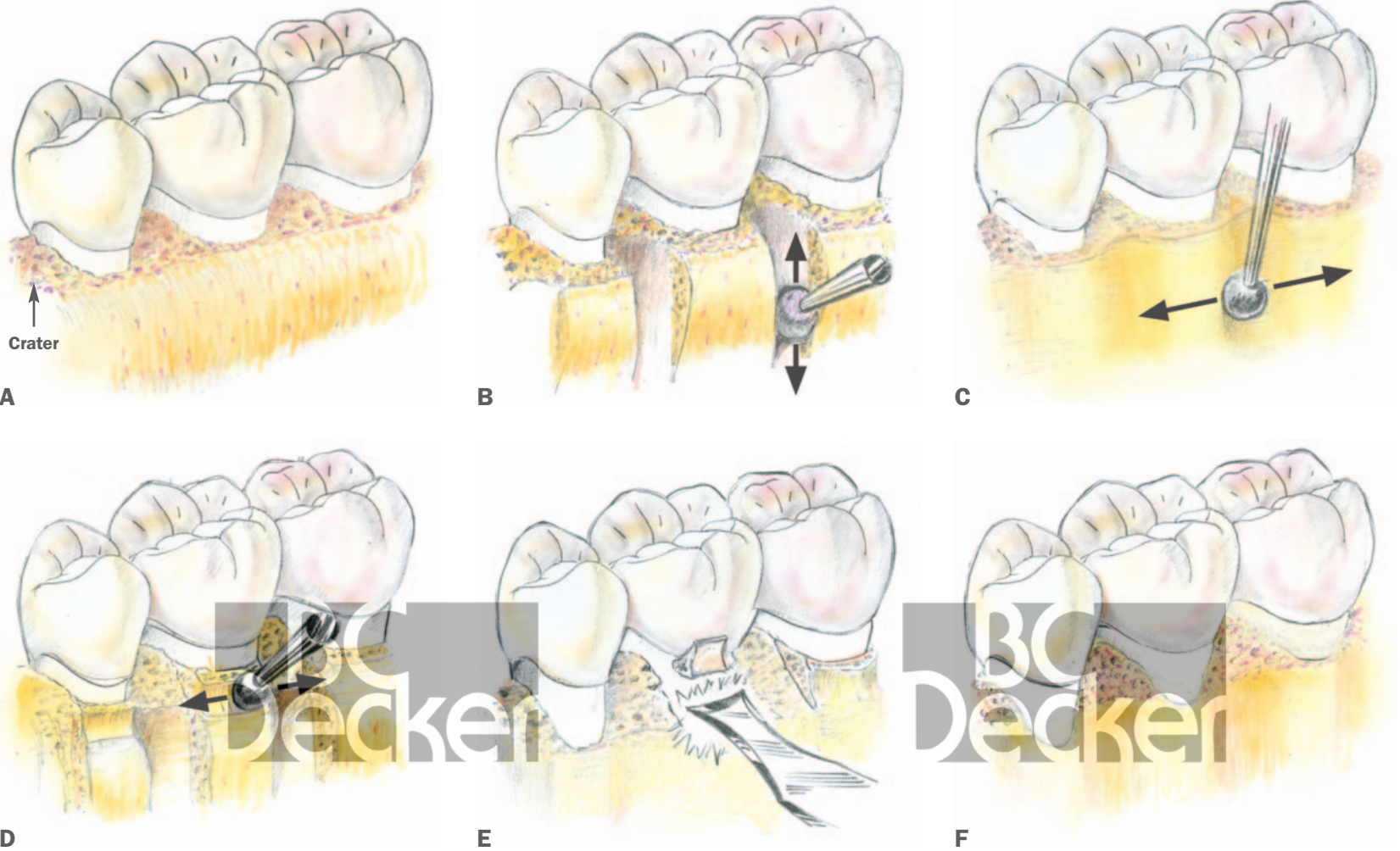


FIGURE 9-4. Osteoplasty for heavy ledges, thick margins, or blunted interproximal septa. A, Depicts thick margins and blunted interproximal septa. B, Vertical grooving to establish width and thin bone interdentally. C, Festooning or radicular blending to reduce thick bony margins and establish a physiologic form. D, Scribing for outlining to be removed. E, Minor ostectomy for the final physiologic parabolic contour. F, Completed reshaping. Note thinned bone with an ideal interproximal contour.

Indications.

1. Sufficient bone remaining for establishing physiologic contours without attachment compromise
2. No esthetic or anatomic limitations
3. Elimination of interdental craters
4. Intrabony defects not amenable to regeneration
5. Horizontal bone loss with irregular marginal bone height
6. Moderate to advanced furcation involvements
7. Hemisepta

Advantages.

1. Predictable pocket elimination
2. Establishment of physiologic gingival and osseous architecture
3. Establishment of a favorable prosthetic environment

Disadvantages.

1. Loss of attachment
2. Esthetic compromise
3. Increased root sensitivity

Contraindications.

1. Areas of insufficient remaining attachment to where osteotomy might unfavorably alter the prognosis of the adjacent teeth
2. Anatomic limitations (eg, prominent external oblique ridge or zygomatic arch)
3. Esthetic limitations (eg, anteriorly, high smile line)
4. Effective alternative treatment

Osteotomy is done by the technique of *spheroiding* or *parabolizing*. Spheroiding or parabolizing is the removal of supporting bone to produce a positive gingival and osseous architecture. An architecture in which the bone is higher interproximally than it is buccally or lingually and has a smooth, even-flowing, scalloped or parabolic

shape on the radicular surface is achieved by the following:

1. Horizontal grooving
2. Scribing
3. Hand instrumentation

Horizontal grooving is the technique by which a small round bur in a high-speed handpiece is placed interproximally at the base of the osseous defect and drawn buccally and lingually. This flattens the interproximal area in a buccolingual direction but not in a mesiodistal direction.

Scribing is the technique by which high-speed rotary instrumentation is used to outline on the radicular bone that bone that is to be removed by hand instrumentation. This scribing provides a visual outline that facilitates the use of hand chisels for final bone removal. High-speed rotary instruments are not to be used for the removal of bone adjacent to teeth for fear of nicking and damaging the teeth.



FIGURE 9-5. Osseous surgery, basic technique. A, Before; interproximal craters with heavy ledges of bone. B, Outline for horizontal grooving. C, Horizontal grooving complete. D, Vertical grooving complete. E, Arrows indicate the direction of spheroiding. F, Spheroiding complete. G, Outline of scribed bone. H, Final case after osteotomy. Compare with A.



FIGURE 9-6. Osteoplasty for reduction of bulbous bone and thick margins. *A, A', B, and B'*, Buccal and occlusal views before treatment showing thick margins and a bulbous osseous contour. Note the blunted interdental septa with no bony defects. *C and D*, Vertical grooving or festooning from buccal and occlusal views. Note that the grooves are carved to the line angles of the teeth. Vertical grooves establish the buccolingual width of the alveolus. *E and E'*, Occlusal view of completed radiculae blending or spheroiding. Note the even-flowing facial contour. *F and G*, Final scalloped or parabolic contour is established with scribing (*F*) and ostectomy (*G*). *H and I*, Final clinical contours established (compare with *A'*) and flap sutured. *J and K*, Before and after views of the gingival contours. Note the thin contoured tissue in the furcation areas (*K*).



FIGURE 9-7. Osteoplasty for buccal ledges, palatal exostosis, and lingual tori. A to D, Before. A' to D', After.

Craters and Hemiseptae

The most common types of intrabony defects are craters and hemiseptae. These are caused by the inflammatory lesion following the blood vessels into the interproximal area, resulting in loss and hollowing of the interproximal bone. The end result produces a negative osseous architecture in which the base of the interproximal bone is below that of the buccal and/or lingual (palatal) radicular surfaces. Without resective osseous procedures for treatment of these defects, tissue pockets will immediately re-form.

The osseous resective techniques employed are the same for craters, hemiseptae, and intra-bony defects.

Procedure

Figure 9-8A represents small interproximal osseous defects or craters in which there is a central loss of interproximal bone while the buccal and lingual radicular walls remain intact. Technically, this is classified as a two-wall intraosseous defect.

Figure 9-8B depicts horizontal grooving. The largest round bur (no. 2, 4, or 6) that can safely fit interproximally without coming in contact with the teeth is placed in the most apical portion of the intrabony defect. It is drawn in a straight line both buccally and lingually (palatally) to flatten and, in effect, remove the interproximal defect in a buccolingual direction.

It is important to note that horizontal grooving, while reducing the interproximal defect, produces a negative osseous architecture, in which the interproximal bone is more apical than the buccal or lingual radicular bone. As a general rule, the osseous resective surgical procedure ideally should result in a positive osseous architecture, with the interproximal bone coronal to the buccal and lingual radicular bones.

In Figure 9-8C, the negative osseous architecture is produced by the horizontal grooving. Spheroiding or parabolizing is begun with osseous scribing along the dotted line. A small no. 2, 4, or 6 round bur is used to scribe the bone.

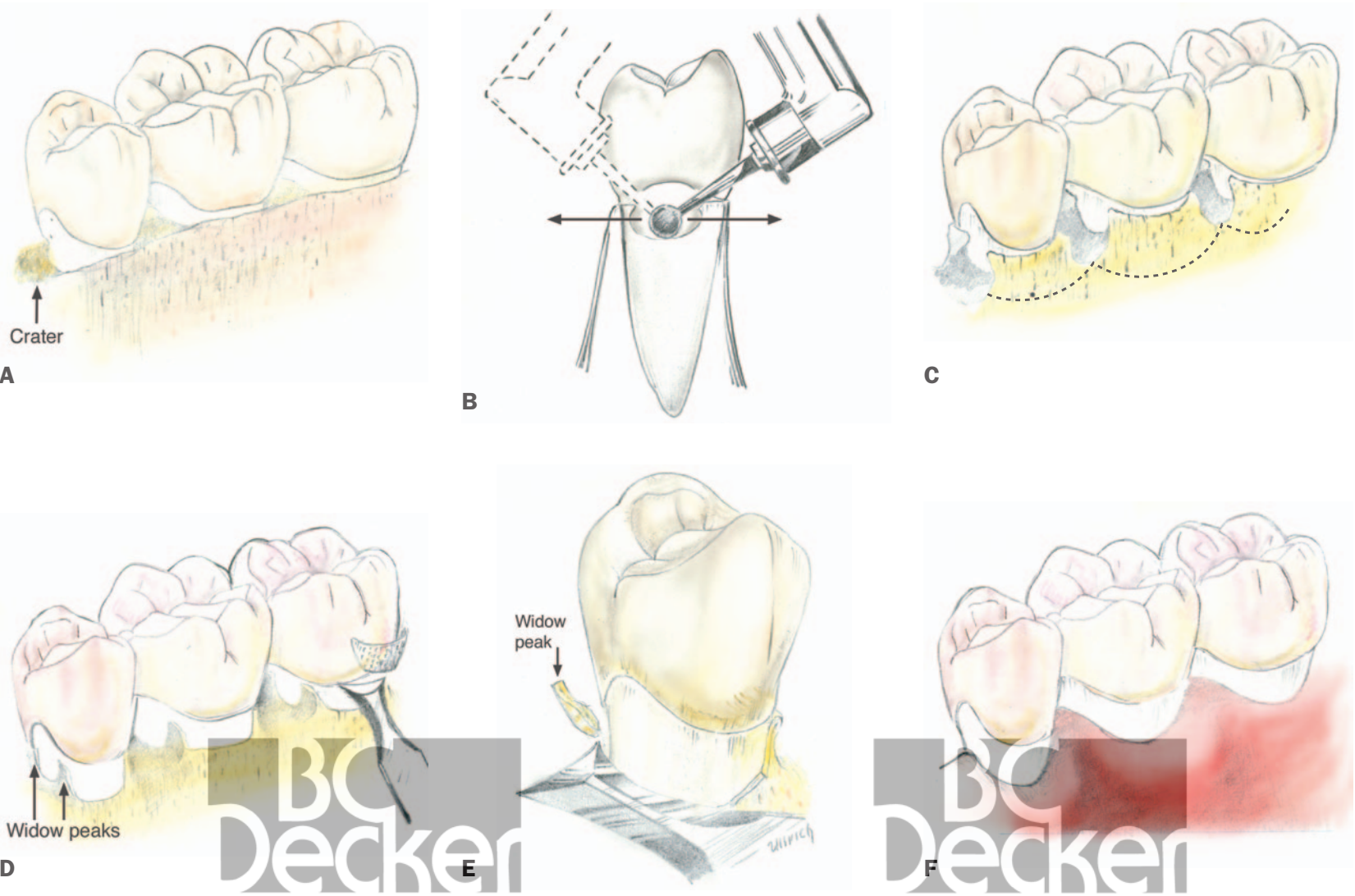


FIGURE 9-8. Osteotomy for osseous deformities: craters, hemiseptae, and intrabony defects. *A* represents interproximal craters. *B*, Horizontal grooving. A small round bur is used to reduce the buccal and lingual crater walls. *C*, Dotted line outlines bone to be scribed prior to removal to establish a physiologic form. *D*, Bone removal with Ochsenbein chisels (after scribing). Note small spicules of residual bone or widow peaks. *E*, Removal of residual bone or widow peaks left at line angles and interproximally. *F*, Osteotomy completed and physiologic form established.

As a rule, scribing should follow the anticipated final desired gingival architecture.

Hand chisels are used to remove bone facially and lingually (Figure 9-8D). This produces the desired scalloped or parabolic osseous form capable of supporting a similar gingival architecture.

The final osseous contouring is performed at the line angles of the teeth to remove small bony spicules, often referred to as widow peaks (Schluger, 1949) (Figure 9-8E). These widow peaks are residual pieces of cortical bone left over from the horizontal grooving that form a crater in a mesiodistal direction. They will not be absorbed and will result in immediate postoperative tissue pocketing. Hand instrumentation with Ochsenbein chisels and various bone files is recommended to remove these residual bony spurs interproximally.

The completed osseous form is shown in Figure 9-8F. Note the positive osseous architecture that rises and falls gradually with a coronally placed, conically shaped interproximal crest of bone.

The procedure is clinically outlined in Figures 9-9 and 9-10.

Management of Deep Craters

In treating craters, it is not always possible to make the center portion of the interproximal bone the most coronal portion (Figure 9-11, A and A') because, in deep craters, too much buccal and/or lingual bone would have to be sacrificed. In these cases, the bone is ramped either buccally or lingually, with only one of the walls totally removed, whereas the other is only partially reduced (Figure 9-11, B and B'). Sometimes the defect is positioned buccally or lingually, favoring removal of only one wall and therefore ramping the bone in that direction (Figure 9-11, C and C').



FIGURE 9-9. Osseous surgery (ostectomy and osteoplasty) for treatment of the osseous crater—example 1. A, Buccal view showing small interdental craters. B, Lingual view. Note heavier lingual ledges and small craters. C and D, Buccal and lingual views of horizontal grooving; note that the interproximal areas are leveled off buccolingually but a small crater is formed mesiodistally (arrows). E, The bone is scribed (outlined areas) prior to removal. F, Lingual view of scribed bone. Some vertical grooving and radicular blending have also been completed. G, Facial buccal osseous contour. Note even-flowing contours; compare with A. H, Final lingual contours. Note scalloped parabolic contours; compare with B.

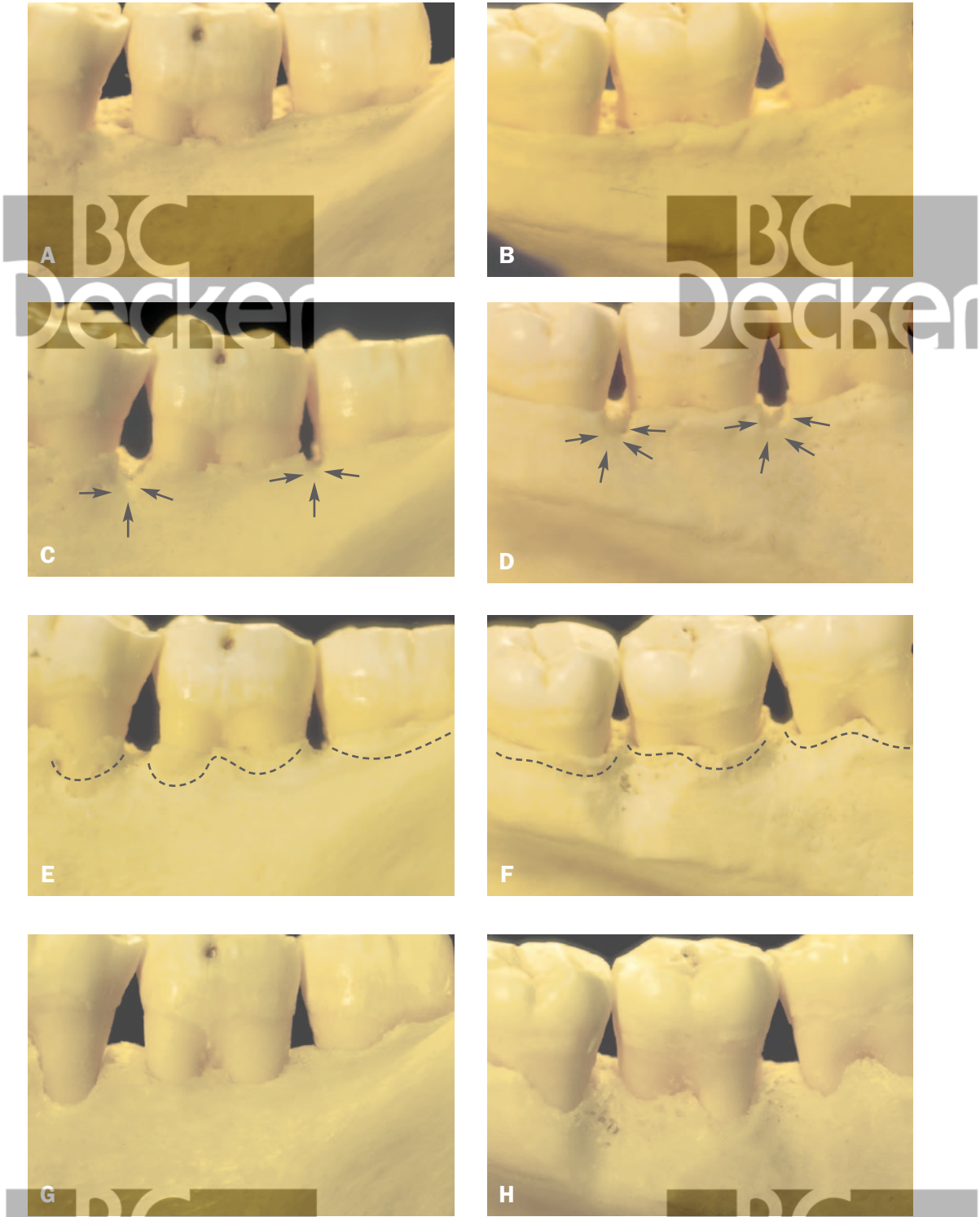


FIGURE 9-10. Osseous surgery (ostectomy and osteoplasty) for treatment of the osseous crater—example 2. A and B, Buccal and lingual views showing small interdental craters. Note the lack of positive osseous architecture. C and D, Horizontal grooving, buccal and lingual views. Arrows indicate residual mesiodistal crater and negative osseous architecture. E, Scribing (*outlined area*) carried to line angles to ensure removal of widow peaks. F, Scribing (*outlined area*) completed on the lingual surface. H, Osseous surgery completed. Note fluid parabolic contours, especially when compared with A and B

Osseous Management of Teeth with Furcations

Osseous resective procedures in areas of furcations often have to be managed with an understanding of the anatomic interrelationships among the following:

1. Length of the root trunk
2. Location and form of the bony defect
3. Furcation involvement and location
4. Alveolar housing
5. Tooth position

The most critical factors are the length of the root trunk and the position and depth of the osseous defect. These two factors ultimately determine the direction (buccal, lingual, or palatal) and amount of osseous corrective procedures necessary to create a positive architecture without involving the furcations.

Maxillary Molars

The maxillary buccal furcation is the primary area of concern in performing osseous resective procedures. Excessive removal of buccal bone (osteotomy) to create a positive gingival architecture may unnecessarily involve this furcation. For this reason, a palatal approach has been recommended (see Chapter 7, “Cosmetic Treatment of Maxillary Anterior Pocketing”). Ramping of bone toward the palate will minimize reduction of buccal bone, maintain esthetics, and, most importantly, preserve the integrity of the buccal furcation.

If buccal resective procedures are required, a scalloped or parabolic form should be created over the mesial and/or distal roots. The buccal furcation should be untouched and allowed to remain coronally positioned. This permits the gingival tissues to rise and fall in a gradual manner, as it does between any two teeth with roots in close approximation.

Mandibular Molars

Tibbetts and colleagues (1976) and Ochsenbein (1986) noted the importance of the lingual axial inclination of the first and second mandibular molars, as a result of which the lingual gingival architecture is usually flat regardless of the buccal gingival contours. Ochsenbein stated that “since the base of the crater is vertical to the contact area...shallow and medium depth crater types generally have their bases located lingually...” Tibbetts and colleagues and Ochsenbein *concluded that the defects should therefore be ramped primarily lingually without attempting to achieve a scalloped or parabolic form over the roots*. They also pointed out the need for osteoplasty on the lingual aspect, especially in the second molar area, to reduce the prominence of the mylohyoid ridge, permitting pocket elimination and adequate gingival form.

Clinical management of complex osseous deformities is shown in Figures 9-12 to 9-14.

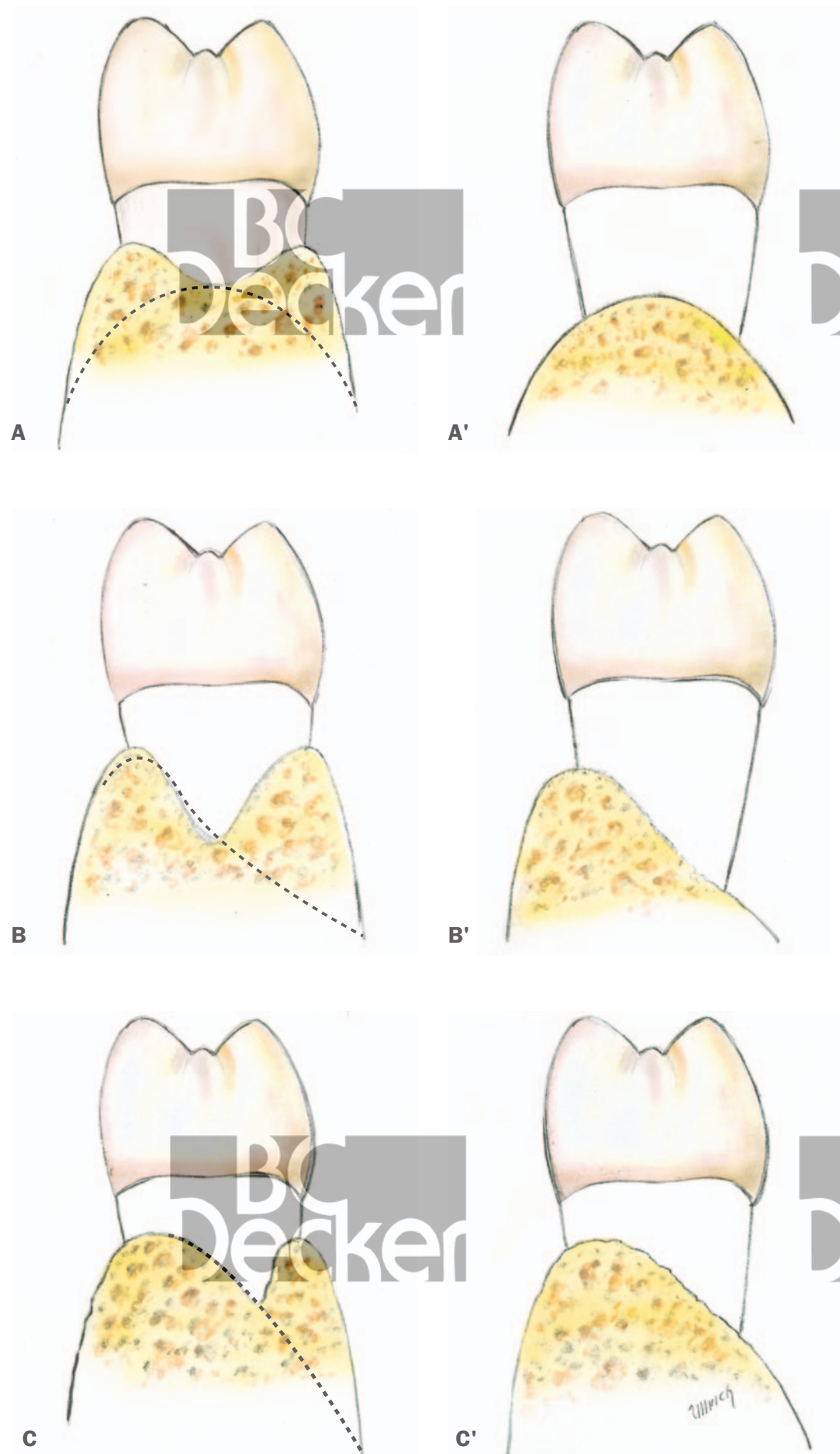


FIGURE 9-11. Osseous correction of the interproximal crater. A and A', Ideal correction of an osseous crater. B and B', Treatment of a deep interproximal crater. C and C', Treatment of a buccally positioned crater.

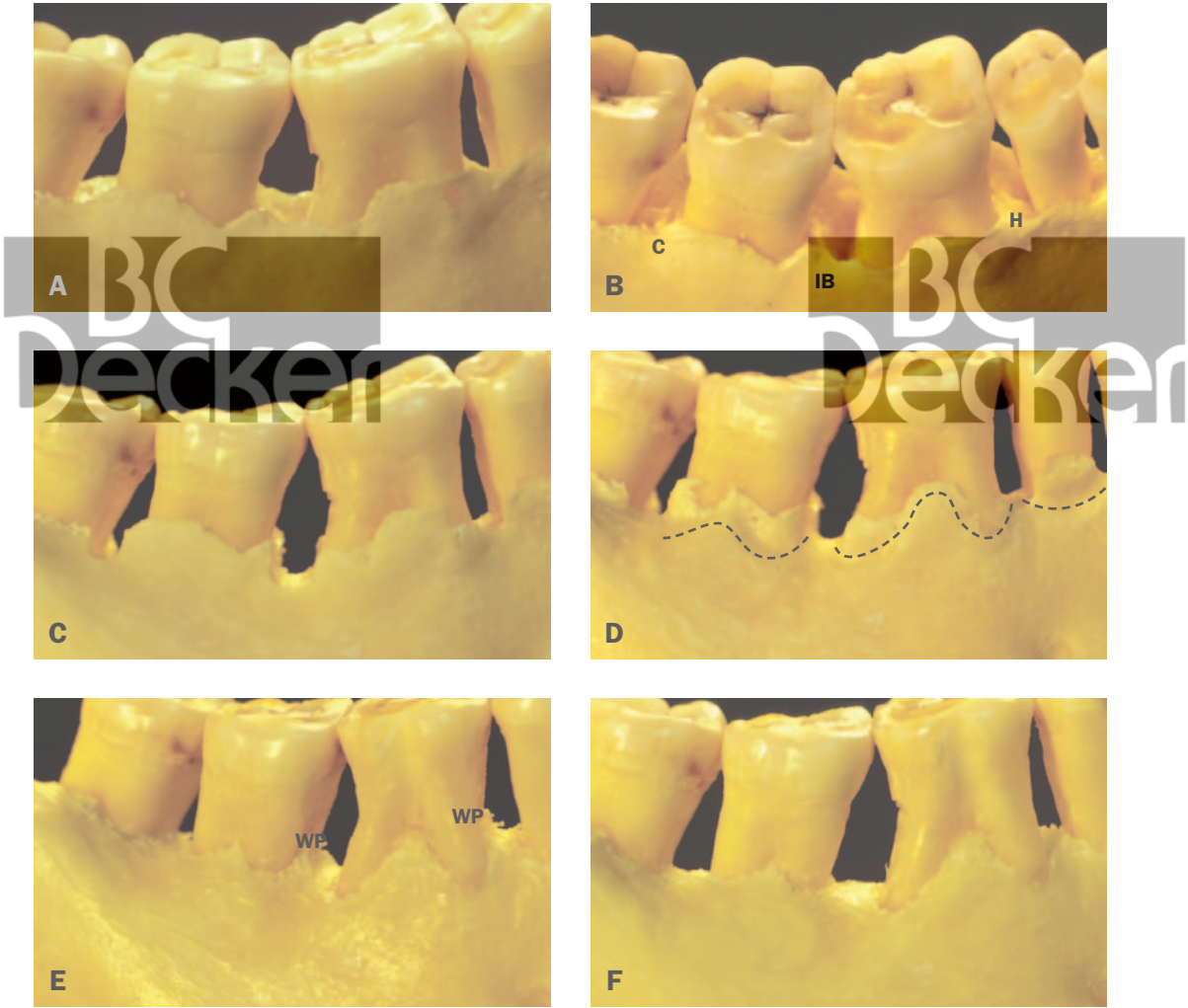


FIGURE 9-12. Osseous surgery for multiple complex intraosseous lesions—example 1. *A*, Buccal view of an irregular marginal osseous contour. *B*, Occlusal view. Note deep intraosseous defects. C = crater. H = hemiseptum; IB = intrabony defects. *C*, Horizontal grooving. Note that the interdental osseous contour is level. *D*, Scribing (*outlined area*) is used to outline the bone to be removed during ostectomy. *E*, Ostectomy completed buccally; small spicules or widow peaks (WP) still remain interproximally. *F*, Osseous contouring completed with interproximal smoothing of bone and no furcation involvement.

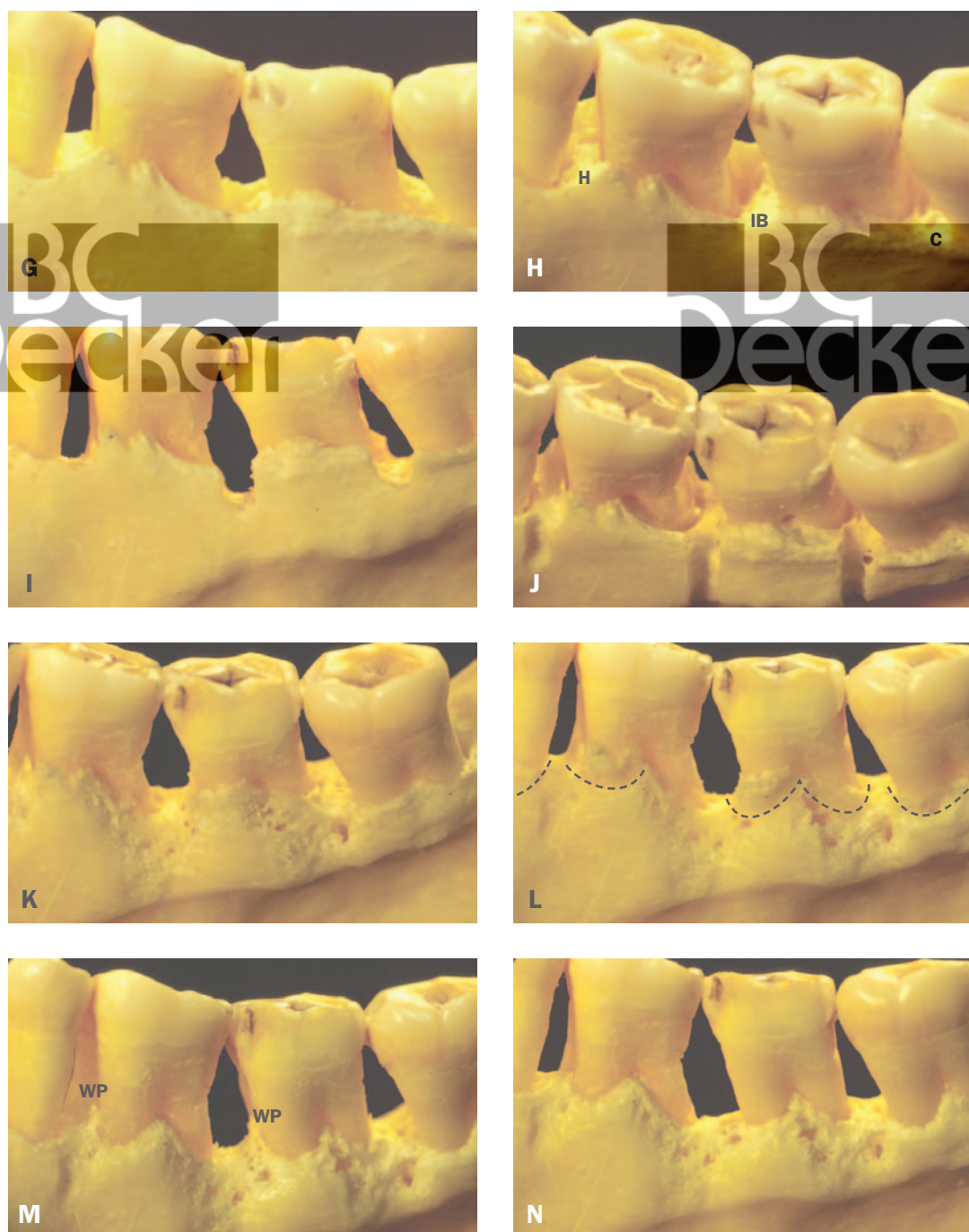


FIGURE 9-12. *Continued.* G, Lingual view with irregular osseous margins. H, Occlusal view of defects. C = crater; H = hemiseptum; IB = intrabony defect; I, Horizontal grooving. Note the level interproximal bone, negative bony architecture, and mesiodistal crater formation. J, Vertical grooving. Note how thick the lingual plate of bone is. Grooves establish the buccolingual width. K, Radicular blending completed. L, Scribing for the final contour completed (*outlined areas*). M, Osteotomy completed lingually, but widow peaks (WP) remain. N, Case complete with smooth-flowing contours and no involvement of furcation areas.

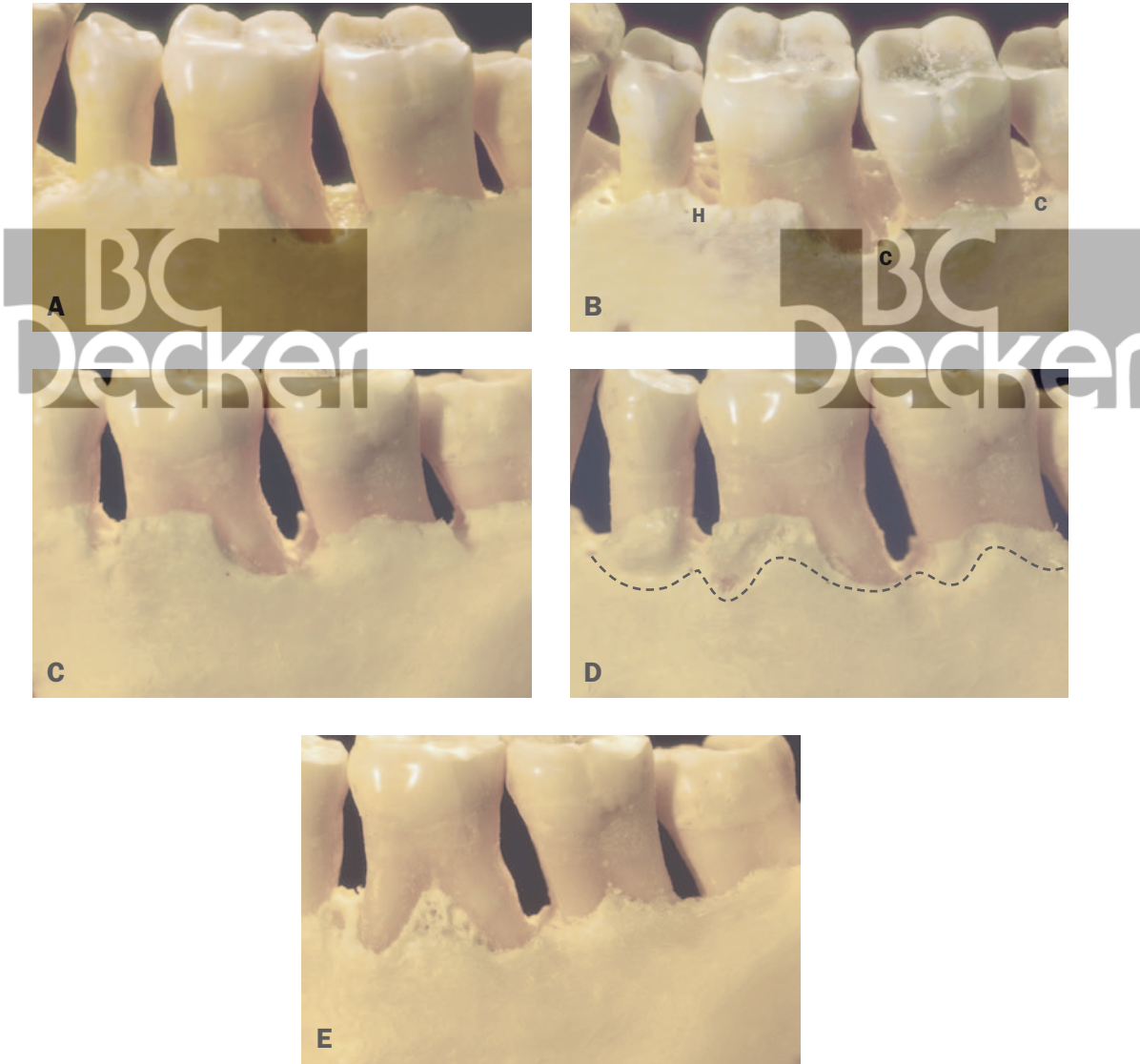


FIGURE 9-13. Osseous surgery for multiple complex intraosseous lesions—example 2. *A*, Buccal view with irregular margins. *B*, Occlusal view showing irregular interproximal contours. *C* = craters; *H* = hemiseptum. *C*, Horizontal grooving. *D*, Scribing to outline the final contour. *E*, Osseous contouring completed: note the scalloped parabolic form without furcation involvement. Compare with *A*.

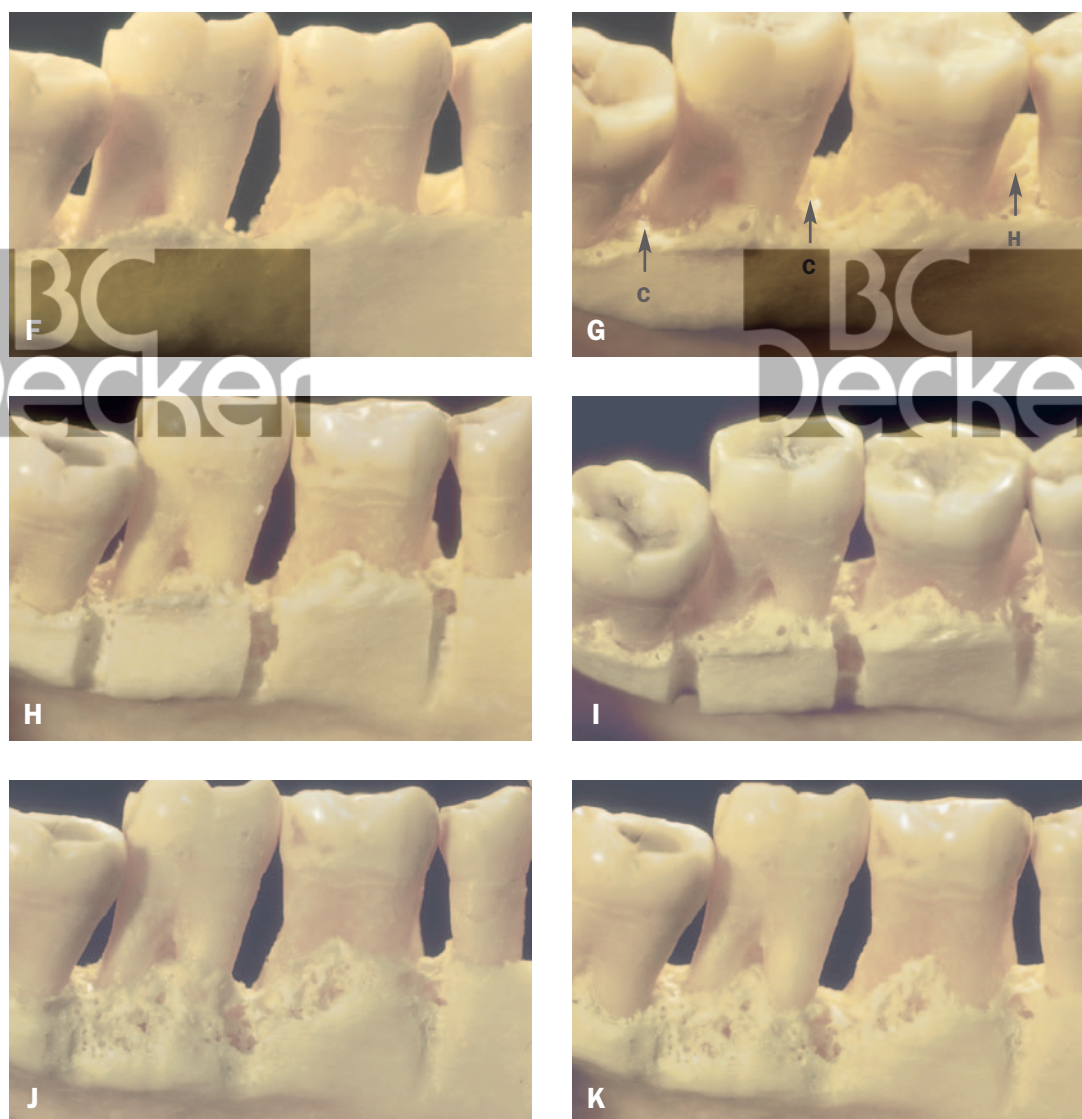


FIGURE 9-13. *Continued.* *F*, Lingual view showing an irregular bone margin. *G*, Occlusal view of interproximal defects. C = craters; H = hemiseptum. *H*, Horizontal and vertical grooving completed elimination of craters and established depth cuts. *I*, Vertical grooves or depth cuts prior to thinning the alveolus, occlusal view. *J*, Radicular blending or festooning complete. *K*, Case completed after ostectomy, with even-flowing, parabolic contours. Compare with *F*.



FIGURE 9-14. Osseous surgery for reduction of bulbous bone and intraosseous defects. *A*, Before treatment. Note the bulbous contour of the bone. *B*, Mucoperiosteal flap reflected, showing an uneven buccal contour with prominent ledges. *C*, Occlusal view showing hallowed-out bulbous bone with deep intraosseous defects. *D*, Probe in place, showing bone fenestration. *E*, Osseous contouring, ostectomy, and osteoplasty completed. *F*, Eight months later, case completed. Originally contributed by Edward D. Cohen, DMD, to *Glickman's Clinical Periodontology* and reproduced with permission of W. B. Saunders Co.

Edentulous Ridge

Defects often occur posteriorly adjacent to edentulous ridges (Figure 9-15). These defects are easily corrected by reducing the edentulous ridge down to the base of the defect (see Figure 9-15). This results in a minimal amount of supporting bone being removed.

Ideally, the molar shown in Figure 11-13 would be uprighted orthodontically, which might reduce or eliminate the need for extensive osseous surgery. It would also promote a more favorable axial inclination for prosthetic rehabilitation.

**Biologic Width/
Crown-Lengthening Procedures**

Restoration of fractured (traumatized), severely decayed, partially erupted (delayed passive eruption), worn, or poorly restored teeth is often difficult, if not impossible, for the dentist. Periodontal exposure or prophylactic lengthening of these teeth must adhere to certain biologic principles and an adequate biologic width must be maintained.

Biologic width is the term applied to the dimensional width of the dentogingival junction (epithelial attachment and underlying connective tissue) (Figure 9-16). Garguilo and colleagues (1961) quantified this as almost a constant 2.04 mm (the epithelial attachment is 0.97 mm, and the connective tissue is 1.07 mm), with a sulcus depth of 0.69 mm.

(For a detailed discussion of biologic width, crown lengthening, and forced eruption, see Part II: Section 2 – Anterior Tooth Exposure).

Basic Rules of Osseous Surgery

In the descriptions of osteoplasty and ostectomy, certain basic principles were noted. These are reviewed here as a checklist for the clinician to follow:

- Rule 1: A full-thickness mucoperiosteal flap should be used whenever osseous resective surgery is contemplated.
- Rule 2a: The scalloping of the flap should anticipate the final underlying osseous

contour, which is most prominent anteriorly and decreases posteriorly.

- Rule 2b: The scalloping of the flap should reflect the patient's own healthy gingival architecture.
- Rule 2c: The degree of tissue and bone scalloping is reduced as the interproximal area becomes broader as a result of bone loss.
- Rule 3: Osteoplasty generally precedes ostectomy.
- Rule 4: Osseous resective surgery should, whenever possible, result in a positive osseous architecture.
- Rule 5: High-speed rotary instrumentation should never be used adjacent to the teeth and should always be used with a generous spray.
- Rule 6: The final bony contours should approximate the expected healthy postoperative gingival form, with no attempt to improve on it.

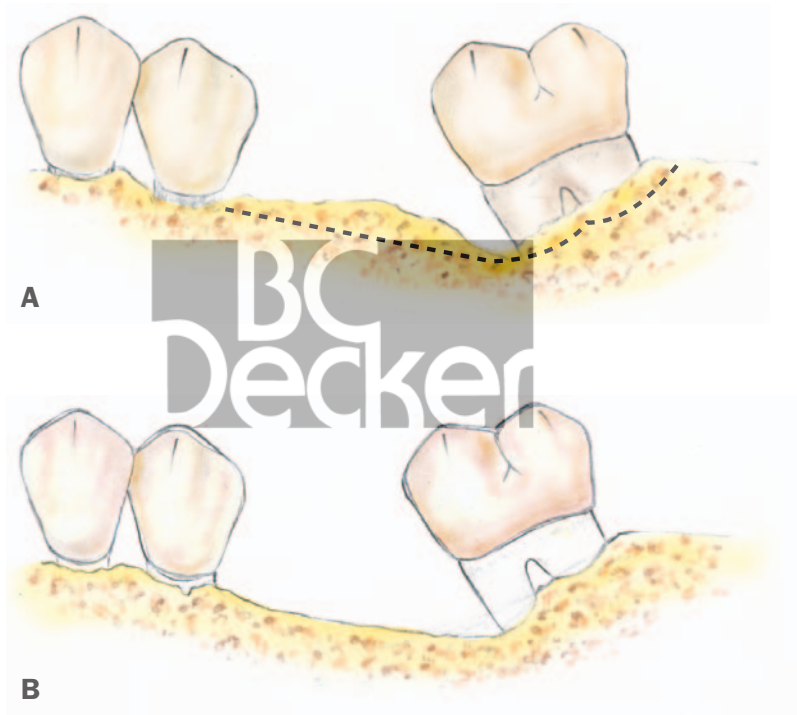


FIGURE 9-15. Osseous resection of edentulous ridge area. A, Note the defect approximating a tilted molar. *Dotted line* outlines bone to be removed to create physiologic architecture. B, Osseous surgery completed.

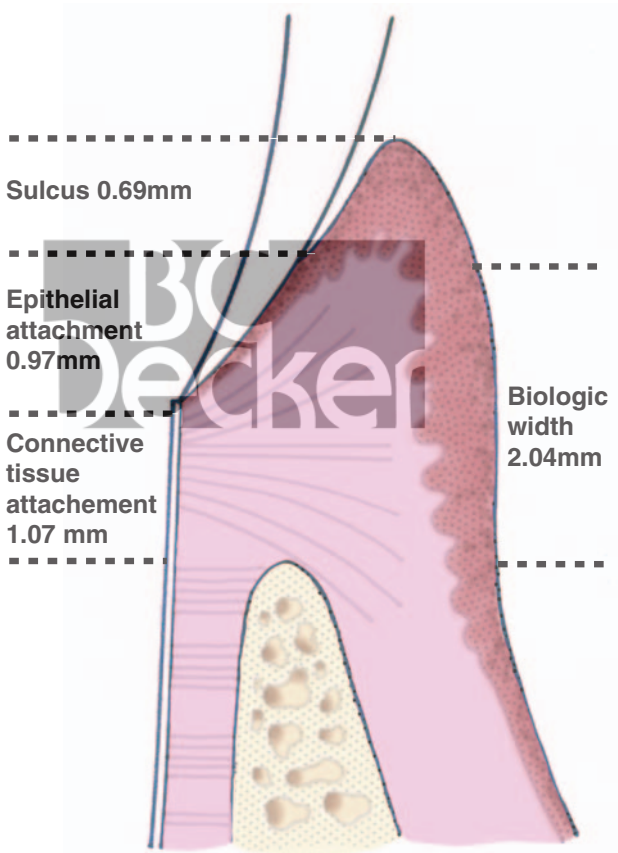


FIGURE 9-16. Biologic width. Representation of the average dimensions of the connective tissue and epithelial attachment above the bone.



Inductive Osseous Surgery

Ideally, periodontal therapy would reconstruct or reconstitute all gingival and osseous structures lost through disease. In an attempt to achieve this, clinicians have long tried with varying degrees of success to induce osseous regeneration, cementum formation, and fibrous attachment to achieve new attachment (reattachment).

The intrabony (infrabony) pocket, which Goldman (1949, 1958) identified, classified (Figure 10-1), and outlined treatment for, offers the greatest chance for regenerative techniques. This is especially true of two- and three-wall–deep, narrow intrabony defects and deep intraosseous craters (Ellegaard and Loe, 1971). They offer an osseous topography that will hold a blood clot, with or without graft material, and that will permit ingrowth or primordial vascular and osseous cells from the bony lateral walls. On the other hand, if the osseous deformity is not amenable to regenerative or inductive procedures, as in the case of one-wall intrabony defects, or is small, as in the case of shallow craters, osseous resective surgery may be the treatment of choice.

Reynolds and colleagues (2003), in a meta-analysis of bone replacement grafts in the treatment of intrabony defects from 1966 to 2002, and the American Association of Periodontology (AAP) position paper on periodontal regeneration (2005) agreed that bone grafts

1. Increase the bone level
2. Reduce crestal bone loss
3. Increase the clinical attachment level
4. Reduce probing depth when compared with open flap surgery
5. Increase clinical attachment level and reduce probing depth when combined with guided tissue regeneration (GTR) compared with grafts alone
6. Support formation of a new attachment apparatus
 - a. autogenous bone grafts
 - b. demineralized freeze-dried bone allografts (DFDBA)
 - c. xenografts (Bio-Oss®, Osteohealth, Uniondale, New York)
 - d. enamel matrix derivative (Emdogain® Straumann, Basel, Switzerland).

Note: All other graft materials support repair.

They concluded that “replacement grafts provide demonstrable clinical improvements in

periodontal osseous defects compared to surgical debridement alone.”

Definitions

The following definitions are from the Proceedings of the World Workshop in Periodontics (WWP) (1989) and the AAP *Glossary of Terms* (2001):

Repair: Healing of a wound by tissue that does not fully restore the architecture or function of the part, as in the case of a long junctional epithelium or ankylosis.

Reattachment: The reunion of connective tissue with a healthy root surface on which viable periodontal tissue is present without new cementum, as in the case of trauma or after a supracrestal fiberotomy.

New attachment: The reunion of connective tissue with an unhealthy or previously diseased root surface that has been deprived of its periodontal ligament. This reunion may or may not occur by formation of new cementum with inserting collagen fibers, as in the case of GTR.

Regeneration: Reproduction or reconstitution of the lost or injured parts by restoration of new bone, cementum, and a periodontal ligament (reunion of connective tissue) on an unhealthy or previously diseased root surface. Ideally, complete restoration would also restore total function.

Intrabony Defects

Preparation for Bone Regeneration and New Attachment

Figure 10-2 graphically portrays the three critical zones to which treatment is applied (Ratcliff, 1966; Glickman, 1972; Wirthlin, 1981):

1. The root surface (see Figure 10-2A [1])
2. The granulosomatous tissue of the defect (see Figure 10-2A [2a]) and the residual transseptal and periodontal fibers covering the bone (see Figure 10-2A [2b])
3. The underlying bone (Figure 10-2A [3])

Treatment of all intraosseous defects is the same and involves the following:

1. Removal of plaque, calculus, softened cementum, and the junctional epithelium from the root surface (see Figure 10-2B)
2. Removal of all granulation tissue from the bony defect (see Figure 10-2C)

3. Removal of all connective tissue and periodontal ligament fibers covering the bone (see Figure 10-2, A and B)
4. Decortification of dense or sclerotic bone (see Figure 10-2D)

Procedure for Treatment of Intrabony Defects

1. Sufficient local anesthesia for hemostasis and greater visualization is required.
2. The final osseous topography is now determined by sounding for the underlying bone with a periodontal probe (Figure 10-3A).
3. A full-thickness mucoperiosteal flap is raised using sulcular incisions (Figure 10-3, B to E).

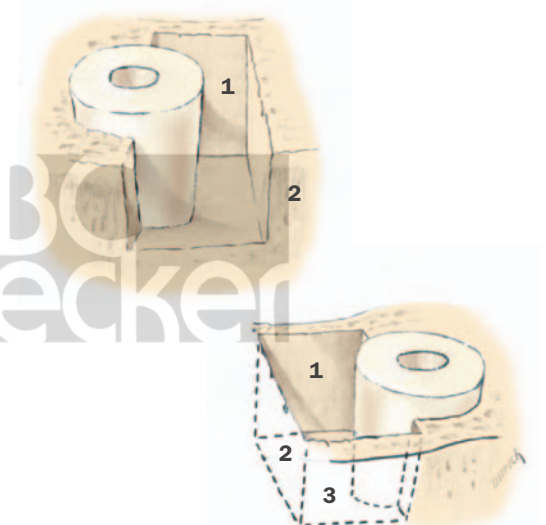
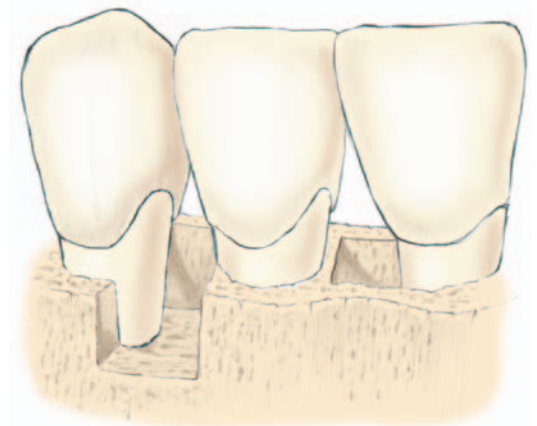


FIGURE 10-1. Classification of intrabony defects. Intrabony defects are classified by the remaining walls and the root surfaces involved.



FIGURE 10-2. Three zones of intrabony defects. A, (1) the root surface; (2a) the soft tissue of the pocket; (2b) the connective tissue fibers covering the bone. (3) The bony defect. B, The plaque, calculus, and soft cementum (1) is removed. C, Removal of the soft tissue pocket (2a) and underlying periodontal fibers (2b). D, Intramarrow perforation of bony housing.

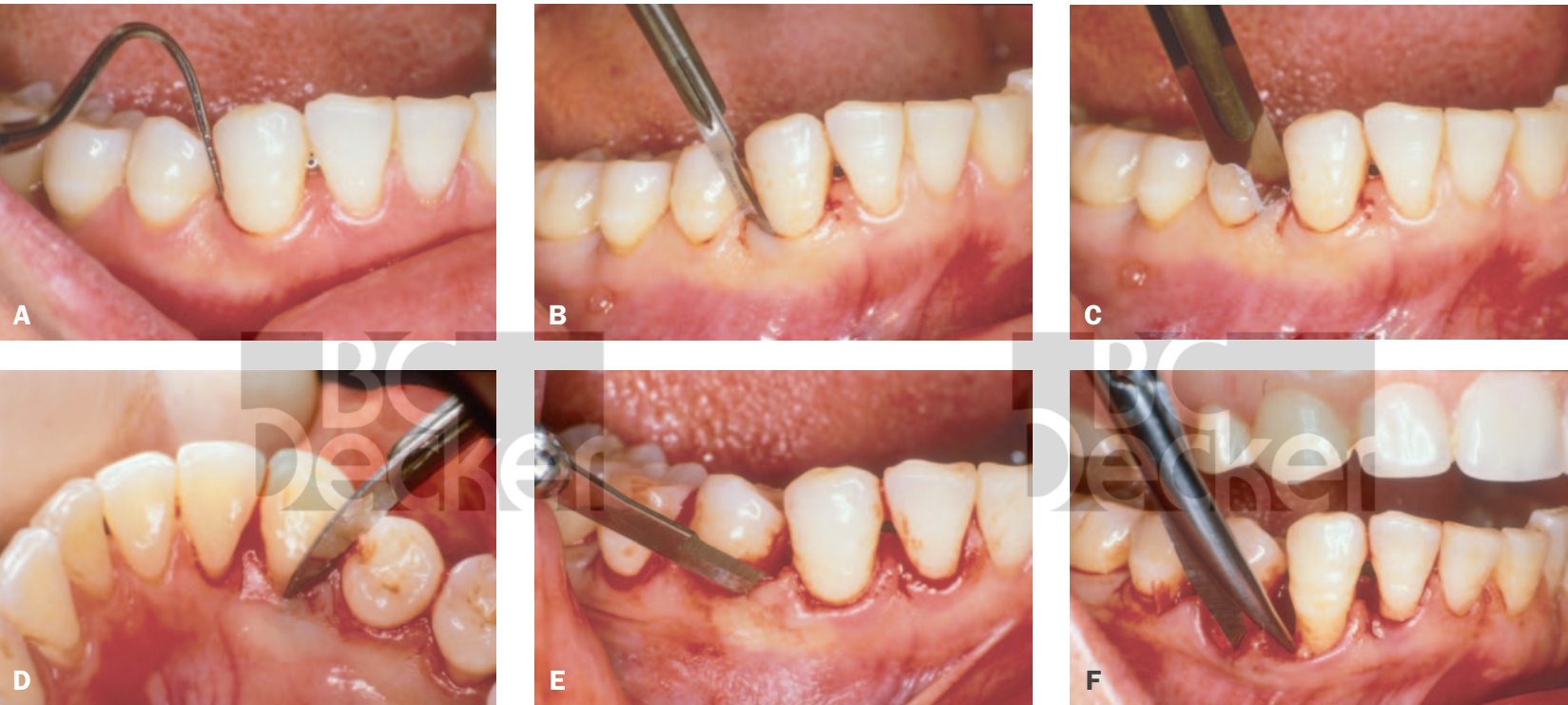


FIGURE 10-3. Surgical technique and placement of demineralized freeze-dried bone allograft (DFDBA). A, Before surgery with the probe in place delineating a 7 mm pocket and intrabony defect. B to D, Buccal and lingual sulcular incisions for minimum preservation of interproximal tissue. E, Papilla being freed from underlying tissue. F, Periosteal elevator for flap reflection. F, Periosteal elevator for flap reflection.

Maximum conservation of interproximal tissue is attempted so that primary closure can be achieved. Figure 10-4 shows differing interproximal incisions for increasing the chances of maintaining primary root coverage interproximally. It is an attempt to

reduce or minimize “dive-back” of the papilla during healing, thus further exposing the graft and the defect.

Additional biomechanical root preparation (citric acid [CA], tetracycline, and ethylenediaminetetraacetic acid [EDTA]) may

now be employed as the final step prior to intramarrow penetration.

Takei and colleagues (1985) published a procedural technique that permits total interproximal coverage that may be useful in certain situations, especially with anterior



FIGURE 10-3. *continued* G, Teeth scaled and root planed. H, Interproximal granulation tissue removed. I, Gross granulation tissue removed. J, Scaling continued for complete osseous débridement. Note complete removal of tissue overlying the bone and exposure of the defect. K, Probe in a small apical three-wall defect. L, Bone decertification and periodontal ligament stimulation. M, DFDBA rehydrated in a sterile dappen dish. N, DFDBA placed with a sterile plastic instrument. O, Defect completely filled. P, Flaps completely replaced and sutured for 1° coverage. Q, One year later. Note the reduction in pocket depth. R, Reentry showing bone regeneration. Courtesy of Dr. James Mellonig, San Antonio, TX.

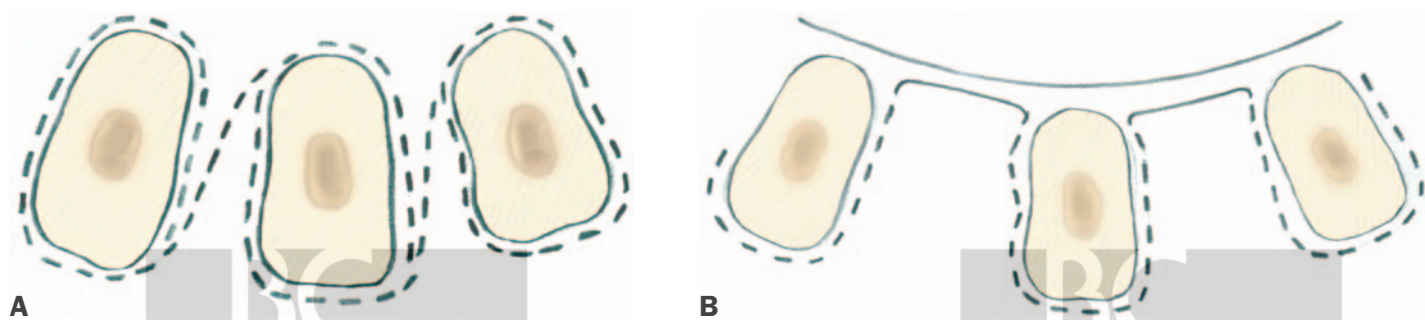


FIGURE 10-4. Interproximal incisions for implant coverage. A, Diagonal incision is made when the interdental space is narrow. This will permit greater surface contact when sutured. B, Wide embrasures permit a “trapdoor” incision to provide complete interdental coverage.

- defects (see Chapter 8, “Cosmetic Treatment of Maxillary Anterior Pocketing,” Figures 8-5 through 8-7). Cortellini updated this procedure in 1995 as the modified flap and again in 2001 as the simplified flap to ensure primary flap coverage.
4. The flap is extended at least one tooth mesial and distal to the defect for exposure of at least 2 to 3 mm of surrounding sound bone (Figure 10-3F).
 5. Vertical releasing incisions are optional.

Once the flaps are reflected, the three zones—root surface, soft tissue, and bone—are addressed.

Zone 1: Root Surface. The root surface must be meticulously scaled and root planed, which is probably the most difficult aspect of treatment (see Figures 10-2B [1] and 10-3G). Scaling alone is not sufficient because it will not remove softened or necrotic cementum, bacterial endotoxins, remnants of the junctional epithelium, or residual calculus. Enamel finishing burs are often used to remove residual calculus and smooth the root surface. If thorough root preparation is not carried out, the root surface may not be amenable to cementogenesis (Stahl, 1977) or be able to sustain the growth of fibroblasts

(Aleo and colleagues, 1975). Some clinicians (Pritchard, 1983), on the other hand, believe that root planing is contraindicated and will prevent cementogenesis.

Zone 2: Soft Tissue. With the flaps reflected, large curets are used against the bony surface to remove all granulation tissue and residual fibers attached to the bone (see Figures 10-2C [2a and 2b] and 10-3, H and I). The tissue is difficult to remove, and the process is tedious. Small curets and ultrasonic instruments are used in the apical recesses and in the periodontal ligament space for curettage and lavage. All fibers must be removed to open the marrow spaces and permit intimate contact between graft material and bone (see Figure 10-3, J and K).

Zone 3: Bone. The bone is gone over with fine curets to remove any residual fibers and to open the marrow spaces. Chronic wounds are often associated with a dense or sclerotic bone that is poorly vascularized and therefore less osteogenic than freshly created defects. For this reason, decertification is performed. Small holes are made in the bone with a sharp curet or small round bur (no. 0.25 to 0.5), permitting (1) rapid proliferation of granulation tissue with undifferentiated mesenchy-

mal cells, (2) rapid regeneration of bone, and (3) rapid anastomosis of graft and bone (see Figure 10-2D). The holes are made into areas of anticipated vascularity. Finally, the periodontal ligament is scraped with the tip of an explorer to promote bleeding and stimulate cell proliferation (see Figure 10-3L).

6. Selection of the graft material(s) (autograft, allograft, alloplast, GTR) to be placed will vary by individual clinical preference, the nature of the defect to be filled (intrabony versus furcation), and the final results sought (regeneration, new attachment, or repair) (Figure 10-3M).
7. The graft material is placed in small increments, and care is taken to pack each increment down adequately while also removing excessive fluid (Figure 10-3N, 10-3O).
8. The graft material may be overfilled, underfilled, or neutrofilled (Figure 10-5). Overfilling will compensate for some loss of graft material but will make primary closure difficult.
9. The flaps are reapproximated with digital pressure over the defect. If there is not 100% defect coverage, the flaps can be further scalloped with a sharp no. 15 scalpel blade on the buccal and/or lingual surfaces to accommodate total coverage (Figure 10-6). **Note: Limited osteoplasty may also help in flap closure.**

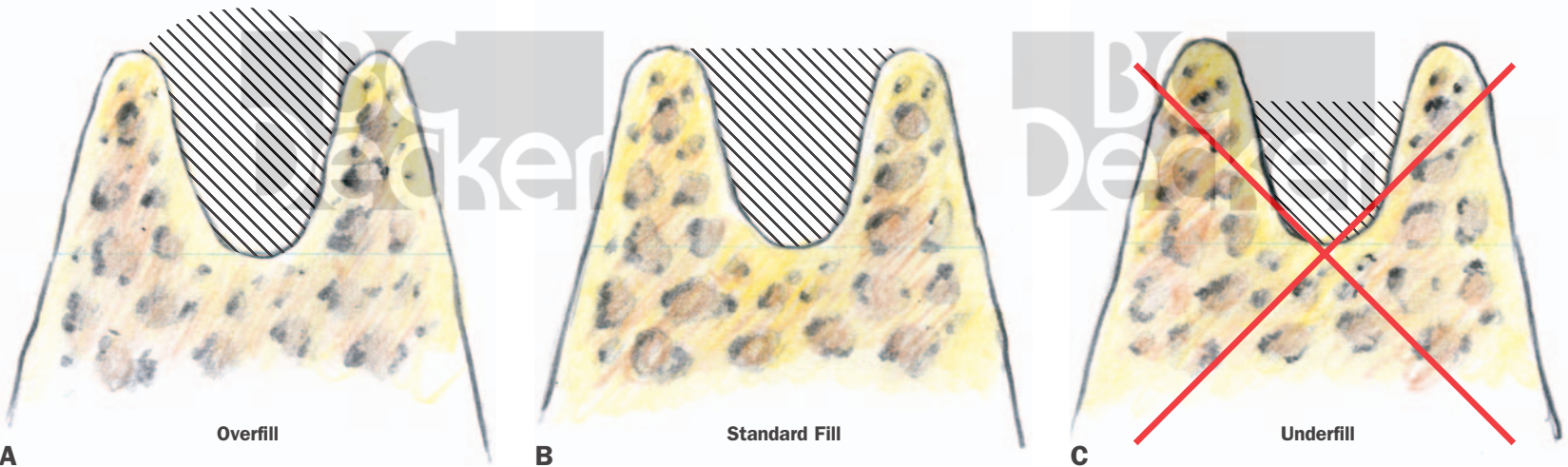


FIGURE 10-5. Intrabony defect size versus quantity of implant material. A to C, Various amounts of implant material that may be placed into defects.

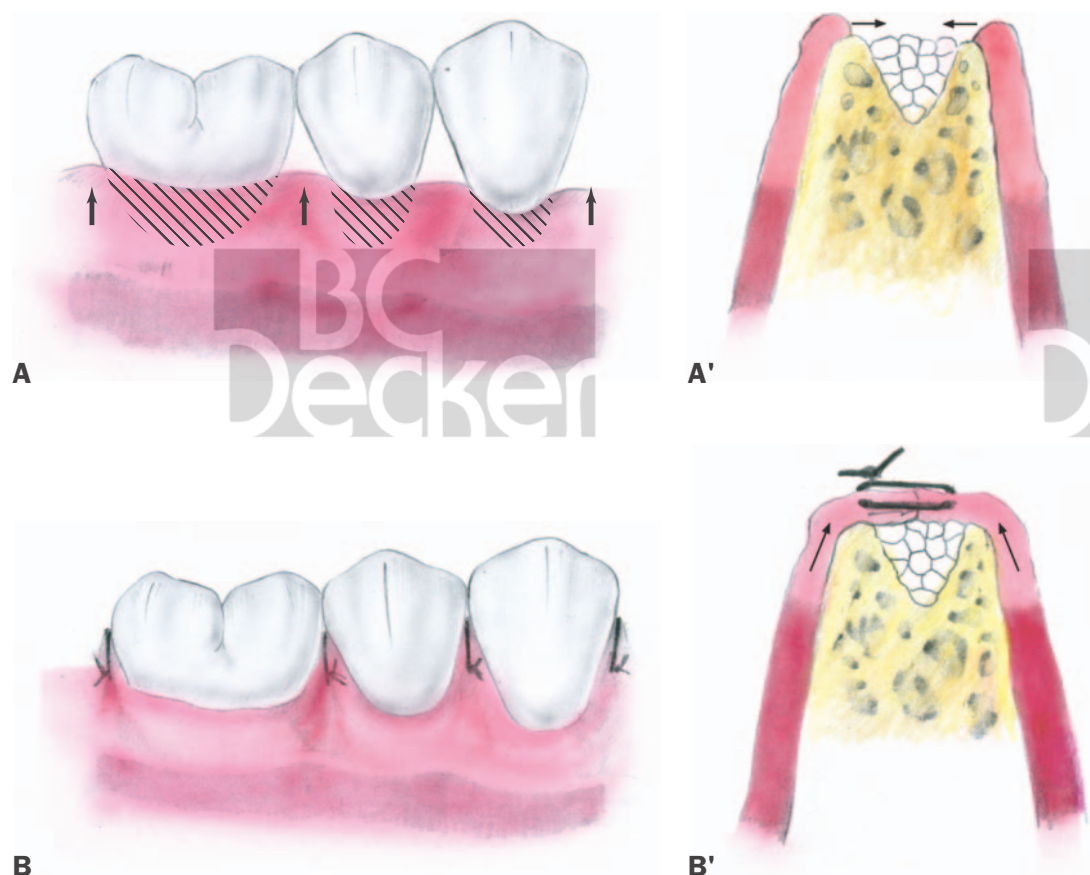


FIGURE 10-6. Flap modification for graft coverage. A and A', Incomplete interproximal flap coverage of a defect. Shaded areas delineate additional scalloping for increasing interproximal coverage. B and B', Additional scalloping has been completed, and 100% implant coverage is achieved.

10. Vertical mattress or intrapapillary suturing is ideally recommended using monofilament, Gore-Tex, or Vicryl sutures (Figure 10-3P). This prevents the wicking of bacteria into the graft site, reduces suture inflammation, and, at the same time, permits retention for 14 days. The longer suture retention increases flap tensile strength and ensures adequate implant coverage.
11. Postoperatively, the patient is placed on doxycycline 100 mg twice daily or tetracycline 250 mg three times daily for 10 to 14 days. The packing is changed after 7 days, and sutures are removed in 14 days. Peridex mouth rinse is recommended for 3 weeks.

Upon completion of the individual steps, and if no graft is to be used, all that remains to be done is flap closure.

The clinical procedure outlining the steps in achieving successful bone regeneration is seen in Figure 10-3. The positive results sometimes obtainable by the basic intrabony technique are shown in Figure 10-7.

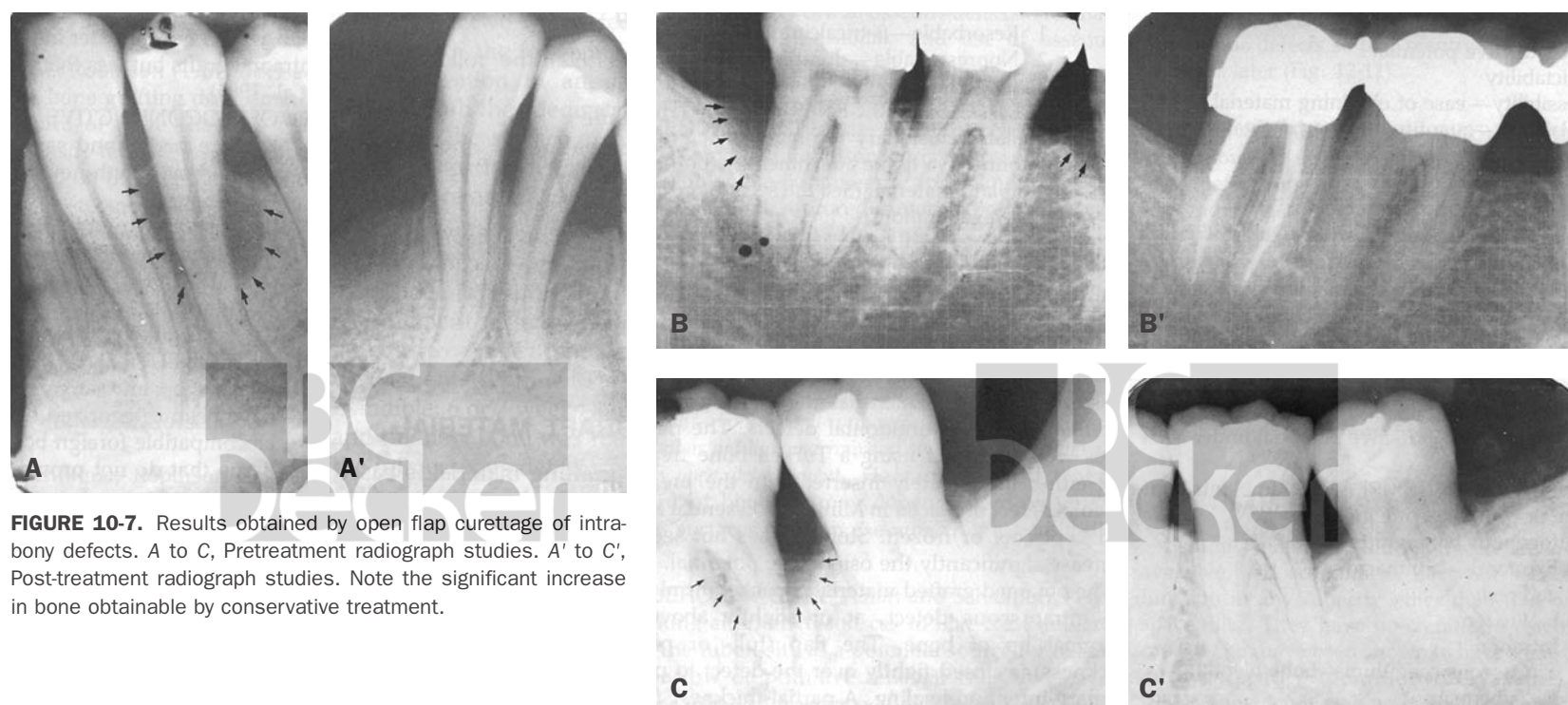


FIGURE 10-7. Results obtained by open flap curettage of intra-bony defects. A to C, Pretreatment radiograph studies. A' to C', Post-treatment radiograph studies. Note the significant increase in bone obtainable by conservative treatment.

Treatment Options

On completion of the individual steps, all that remains is for the clinician to choose one of the following options:

- 1. Open flap débridement (OFD)
- 2. Bone grafts (DFDBA, Osteohealth, NY; Emdogain Bio-Oss)
- 3. Guided tissue regeneration
- 4. Biologic mediators (enamel matrix derivative)

Table 10-1 shows the clinical attachment level gains (CAL-Gs) for the different treatment options. Note the significant differences in CAL-Gs of grafting GTR and enamel matrix derivative over OFD.

Bowers and colleagues (1982), in their literature review of human histologic material on regeneration in intrabony defects, concluded that in areas adjacent to bone implants, cementogenesis and osteogenesis appeared to be enhanced. This was as opposed to nongrafted sites, which tended to show less bone fill, less cementogenesis, and greater likelihood of heading by a long junctional epithelium. Since then, only DFDBA, Bio-Oss, Endogain, GTR, and CA have been able to show human histologic evidence of regeneration.

Factors Affecting the Success or Failure of Regeneration Procedures

According to Mellonig (1992), the following factors affect the success or failure of regeneration procedures:

- 1. Plaque control
- 2. Underlying system disease (eg, diabetes)
- 3. Root preparation
- 4. Adequate wound closure
- 5. Complete soft tissue approximation
- 6. Periodontal maintenance, short and long term
- 7. Traumatic injury to teeth and tissues
- 8. Defect morphology
- 9. Type of graft material
- 10. Patient's repair potential

Table 10-1 Intrabony Defects			
Procedure	No. of Cases*	CAL-G (mm) Mean ± SD	CAL-G (mm) 95% CI
OFD	1,172	1.8 ± 1.4	1.6–1.9
DFDBA	407	2.8 ± 1.6	2.5–3.1
EMD	480	3.5 ± 1.6	3.2–3.7
GTR	1,283	3.8 ± 1.7	3.7–4.0

Adapted from Tonetti and Cortellini (2001) and Tonetti (2004).
CAL-G = clinical attachment level gain; CI = confidence interval; DFDBA = demineralized freeze-dried bone allograft; EMD = enamel matrix derivative; GTR = guided tissue regeneration; OFD = open flap débridement.
*All cases published in the literature up to 2001.

Failure to Achieve Bone Regeneration

Failure often is not attributable to preparation but to rapid epithelial downgrowth (Ramfjord, 1971). Epithelial proliferation apically, being more rapid than that of connective tissue or bone regeneration, will continue along the root until it encounters granulation tissue and then stop, a process known as contact inhibition.

Pritchard (1983), who has had a great deal of success with regeneration, in describing his successful technique stated that “epithelium must be prevented from growing into the defect. Replacing the flap over the orifice of the defect is probably the most common cause of failure.” As a means of avoiding this error, he counseled that “the gingival tissue must be removed to the vestibular and oral margins of the bony walls of the defects.” In effect, he allows for healing by secondary intention and stunting of epithelial downgrowth by bony exposure. His results were confirmed by Becker and colleagues (1986).

Ellegaard and colleagues (1974) and Karring and Ellegaard (1976), using free soft tissue grafts to cover the orifice of intraosseous defects, found that they could achieve epithelial retardation and greater bone fill than in similar defects covered with flap tissue (see the section on GTR). They hypothesized that the grafts prevented epithelial proliferation while allowing granulation tissue to develop adequately.

To prevent failures and at the same time increase the bone's capacity to regenerate attachment, osseous enhancement and inductive procedures have been developed.

Grafting for New Attachment

Rationale, Objectives, Selection

The primary rationale for using graft materials in intrabony defects is to enhance the regenerative capability of bone and achieve a new attachment apparatus. In the process, we seek to achieve most, if not all, of the following objectives (Goldman and Cohen, 1979):

- 1. Osteoinduction (Urist and McLean, 1952): a process by which graft material is capable of promoting
 - a. Osteogenesis
 - b. Cementogenesis
 - c. New periodontal ligament
- 2. Osteoconduction (Urist and colleagues, 1958): the graft material acts as a passive matrix, like a trellis or scaffolding for new bone to cover over itself
- 3. Contact inhibition (Ellegaard and colleagues, 1976): the process by which the graft material prevents apical proliferation of the epithelium

Advantages of Grafting

The overriding advantage is the potential regeneration of noncorrectable periodontal defects.

Disadvantages of Grafting

According to Mellonig (1992), the following are the disadvantages of grafting:

- 1. Increased treatment time
- 2. Longer postoperative treatment
- 3. Autografts require two sites
- 4. Increased postoperative care
- 5. Variability in repair and predictability
- 6. Need for multistep therapy—secondary surgeries
- 7. Greater expense
- 8. Availability of graft material

Selection of Graft Material

Selection of the specific grafting material is based on a number of factors, each of which must be evaluated. The following are some of the determining factors used in the selection process (Bell, 1964; Schallhorn, 1976):

- 1. Osteoinductive potential
- 2. Predictability
- 3. Accessibility—ease of obtaining material
- 4. Availability—quantity of material obtainable
- 5. Safety
 - a. Biologic compatibility
 - b. Immunologic acceptability
 - c. Minimal sequelae—preoperatively and postoperatively
- 6. Rapid vascularization

Classification

This classification of graft material is based on the degree of inductive potential. The materials are listed in decreasing order of inductive potential under each heading.

Osteoinductive Implants. Osteoinductive implants induce or promote bone growth.

Autogenous Bone Grafts.

- 1. Extraoral—hip marrow
 - a. Fresh
 - b. Frozen
- 2. Intraoral
 - a. Osseous coagulum—bone blend
 - b. Tuberosity
 - c. Extraction sites
 - d. Osseous coagulum
 - e. Contiguous autograft

Allografts.

- 1. Demineralized freeze-dried bone allografts
- 2. Freeze-dried bone allografts (FDBAs)/autogenous bone grafts (ABGs)
- 3. Freeze-dried bone allografts

It is important to note that the DFDBAs and the FDBAs/ABGs have greater inductive potential than the intraoral grafts but less than the hip marrow (Bowers and colleagues, 1985).

Osteoconductive Implants. Osteoconductive implants are passive and serve only as a lattice to be covered over with new bone and replaced.

Allografts.

1. Freeze-dried bone allografts
2. Demineralized freeze-dried bone allografts

Alloplasts.

1. Porous hydroxyapatite

Xenografts

Osteoneutral Implants. Osteoneutral implants are totally inert and serve only as space fillers. They have been categorized by Froum and col-

leagues (1982) as biocompatible foreign bodies within the gingival tissue that do not provide a framework for new bone to cover.

Alloplastic Materials

1. Resorbable— β -tricalcium phosphate
2. Nonresorbable—durapatite, hydroxyapatite (hard tissue replacement [HTR])

Guided Tissue Regeneration. Guided tissue regeneration is an epithelial exclusionary technique that promotes new connective tissue attachment without use of any implant material (see the section on GTR).

Autogenous Bone Marrow Grafts

Extraoral Sites. Schallhorn (1967, 1968), in an attempt to obtain adequate osteogenic donor material for grafting, chose hip marrow, which

has the highest inductive potential, to treat periodontal defects. The marrow cores were obtained using a Turkell bone trephine and either immediately inserted into the prepared osseous defect or placed in minimum essential media and kept cool or frozen. Storage does not seem to decrease the osteogenic potential significantly.

The obtained grafted material is packed firmly into the intraosseous defect, at or slightly above the marginal lip of bone. The flap (full or partial thickness) is closed tightly over the defect to permit primary intention healing. A partial thickness flap is used if a free soft tissue graft is to be used for coverage (Figure 10-8).

His marrow implants, although offering excellent results in two- and three-wall intraosseous defects and even providing supracrestal apposition (Dragoo, 1973a, 1973b; Hiatt and Schallhorn, 1973), displayed such negative factors

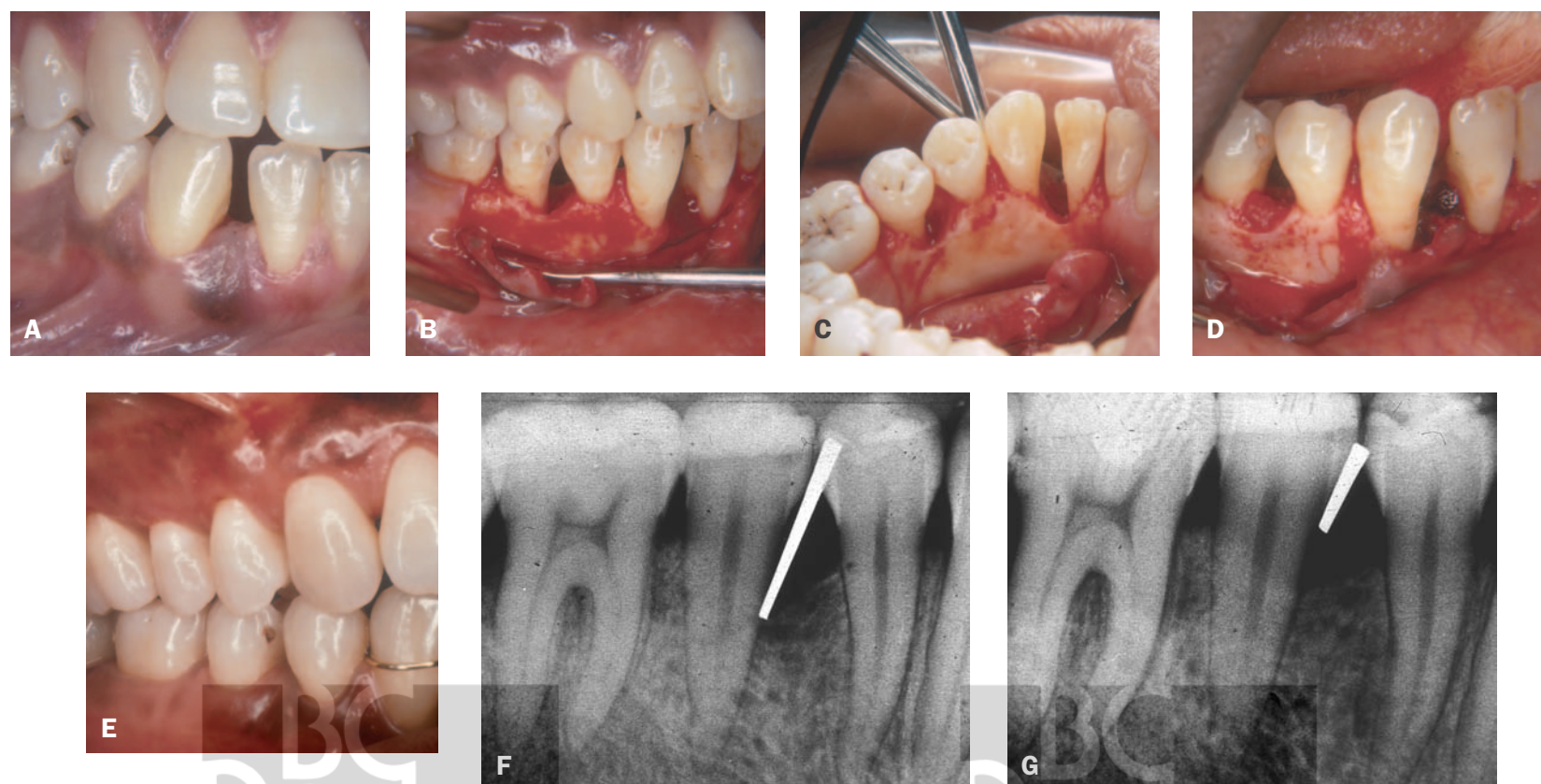


FIGURE 10-8. Autogenous hip marrow implant. *A*, Before treatment. *B*, Mucoperiosteal flap reflected showing the defect on a second premolar. *C*, Lingual view of intrabony defects. *D*, Hip marrow placed in a defect between the premolars. *E*, Seven months later. *F*, Osseous defect with a metal point at the base of the pocket prior to treatment. *G*, Seven months later, the metal point at the base of the pocket and bone repaired. Originally contributed by Edward S. Cohen, DMD, to Glickman's *Periodontology* and reproduced with permission from W.B. Saunders Co.

as ankylosis and root resorption, which preclude their routine use in periodontal surgery (Ellegaard and colleagues, 1976).

Intraoral Sites. Intraoral autogenous bone grafts used for the treatment of periodontal intrabony defects have been shown to have an overall mean bone fill of 3.0 to 3.5 mm, with sig-

nificant gains in probing attachment level (Nabors and O’Leary, 1965; Hiatt and Schallhorn, 1973; Froum, 1976;) when treating one-, two-, or three-wall (or combination) defects. Although human histologic evidence of regeneration was demonstrated (Ross and Cohen, 1968; Naber, 1972), the results were not always predictable (Listgarten and Rosenbert, 1979).

Note: The following instruments are particularly useful for obtaining intraoral autogenous bone:

- 1. Bone trap (Salvin Dental, North Carolina): used for collecting osseous coagulum (Figure 10-9)
- 2. Maxillon bone retrieval device (Maxillon Co., Hollis, NH): used for collection of bone shavings (Figure 10-10)



FIGURE 10-9. Bone trap (Salvin Dental, North Carolina) for collection of osseous coagulum. A, Basic bone trap. B, Bone trap after collection. C, Bone being removed from the trap. D, Trap after bone removal. E, Osseous coagulum collected. Note that if there are tori or exostoses, enough material can be collected to fill a number of defects.

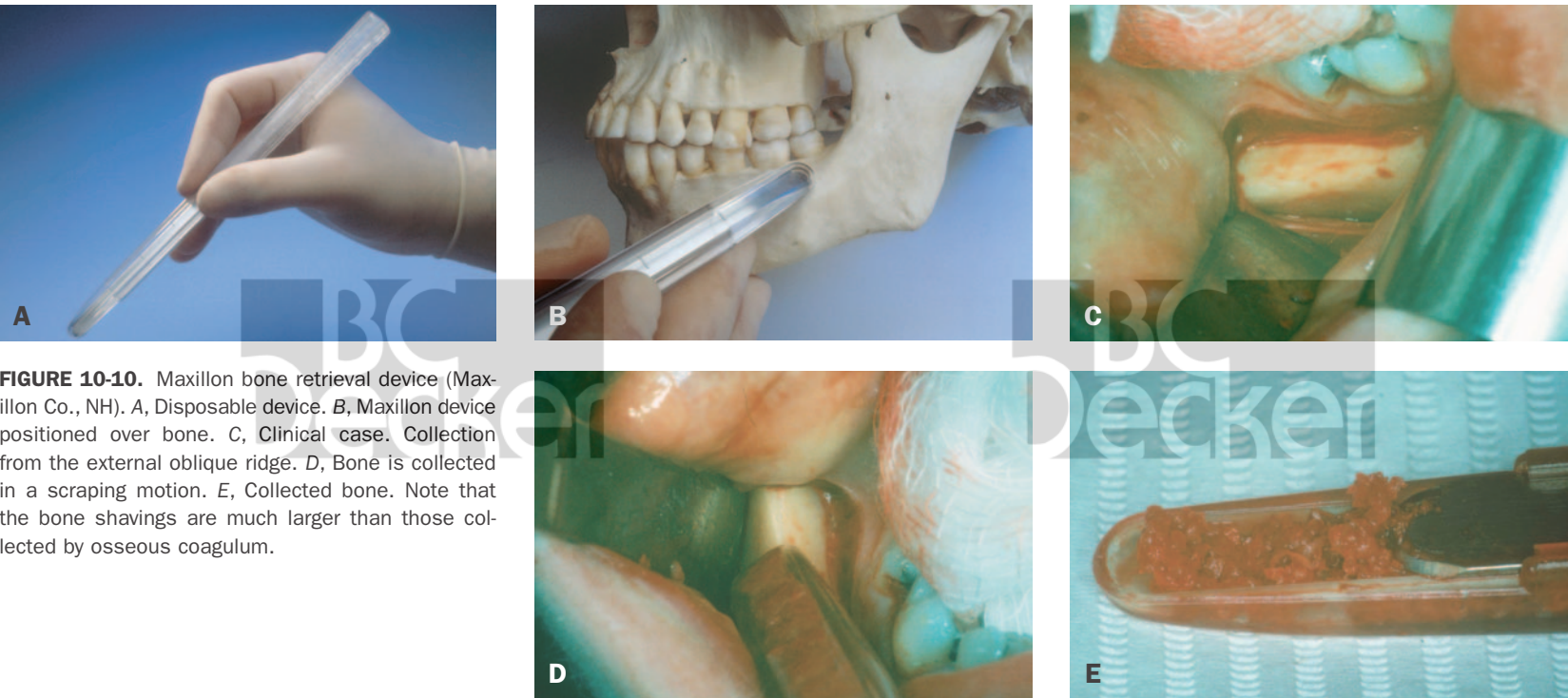


FIGURE 10-10. Maxillon bone retrieval device (Maxillon Co., NH). A, Disposable device. B, Maxillon device positioned over bone. C, Clinical case. Collection from the external oblique ridge. D, Bone is collected in a scraping motion. E, Collected bone. Note that the bone shavings are much larger than those collected by osseous coagulum.

Osseous Coagulum. Robinson (1969) devised a technique for obtaining bone grafting donor material consisting of a mixture of bone shavings and blood from the surgical field, termed *osseous coagulum*. The concept was based on the fact that mineralized substances can induce osteogenesis; it appears to be an extension of the technique developed by Nabers and O'Leary (1965).

The shavings were obtained during osteoplasty. They were collected on a large retractor or mirror and mixed with the patient's blood in a sterile dappen dish (Figure 10-11). The most suitable sites for obtaining bone shaving are exostoses, tori, heavy marginal ridges, and adjacent sites undergoing osseous correction.

In summarizing his techniques, Robinson claimed significant fill in three-wall defects but unpredictable repair of one- and two-wall osseous defects. Freeman (1973) questioned the ability and use of osseous coagulum to enhance bone regeneration.

Osseous Coagulum—Bone Blend. Diem and colleagues (1972) modified Robinson's original osseous coagulum technique to permit easier access and collection of donor material, a procedure termed *osseous coagulum—bone blend*. They used a sterile capsule and pestle to mix or blend the bone obtained from extraction sites, exostoses, tori, or edentulous ridges. The bone spicules (can-

cellous and cortical), obtained with chisels and rongeurs, were triturated for 60 seconds to produce a homogeneous mass, which could easily be placed in a bony defect and firmly packed inside.

Froum and colleagues (1975a, 1975b, 1976) found that osseous coagulum—bone blend provided the same regenerative potential as did iliac marrow and significantly greater regenerative potential than that of open débridement. They further noted that the amount of bone fill may depend more on available osseous surfaces than on the number of osseous walls.

Tuberosity Sites. Hiatt and Schallhorn (1973), in seeking alternative sources to iliac crest

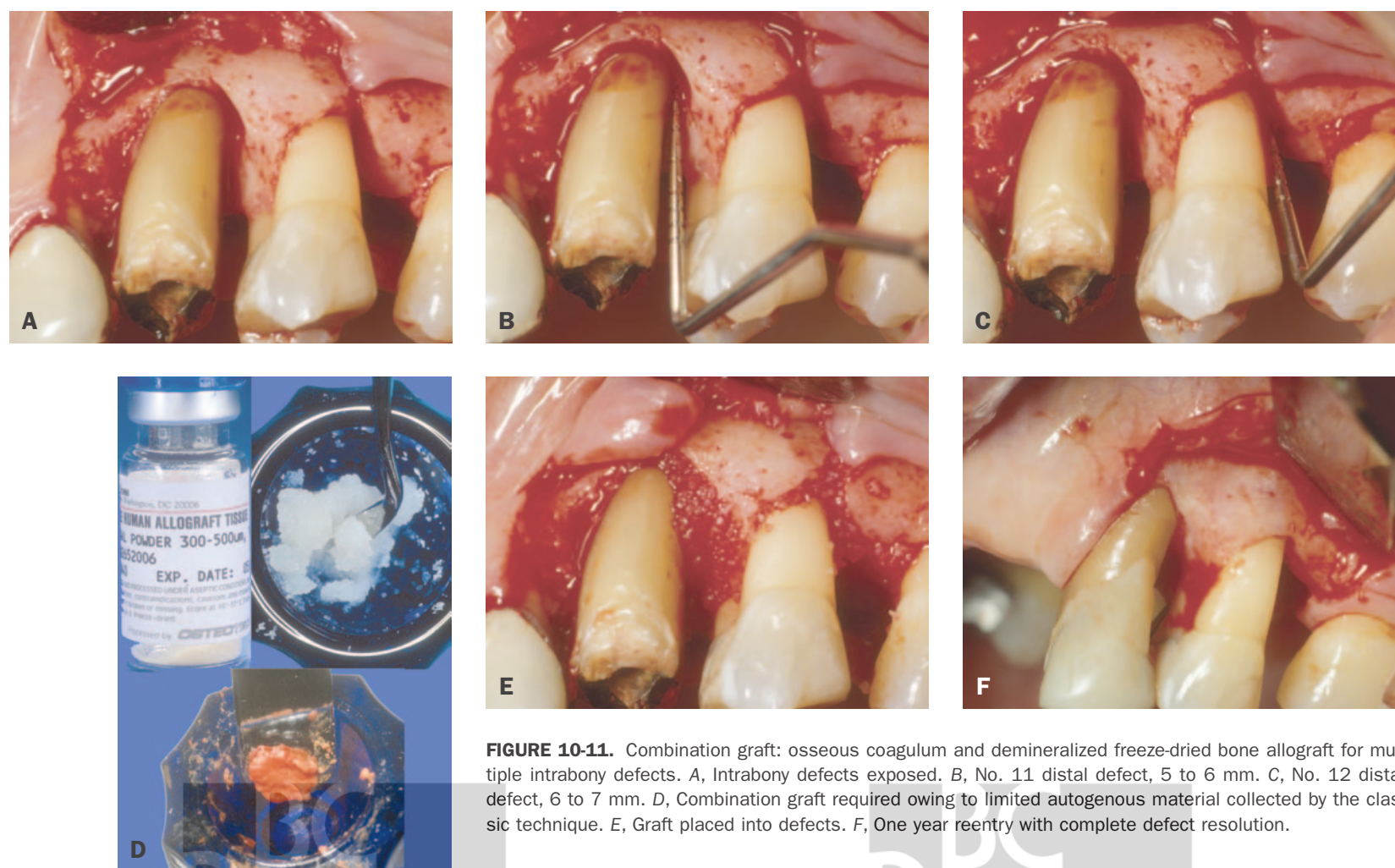


FIGURE 10-11. Combination graft: osseous coagulum and demineralized freeze-dried bone allograft for multiple intrabony defects. A, Intrabony defects exposed. B, No. 11 distal defect, 5 to 6 mm. C, No. 12 distal defect, 6 to 7 mm. D, Combination graft required owing to limited autogenous material collected by the classic technique. E, Graft placed into defects. F, One year reentry with complete defect resolution.

implants, chose the tuberosity as a potential source for residual red marrow or primitive reticular cells that have a pluripotential competence. At the very least, they believed, cancellous bone was a potential source of large numbers of

osteoblasts. The cancellous bone was obtained after careful removal of the cortical plate by use of rongeurs and cone curets (Figure 10-12). After treating 166 intrabony defects with cancellous bone implants from the tuberosity, extrac-

tion sites, and edentulous ridges (Figure 10-13), they noted that total regeneration was obtained in three-wall defects but only partial fill of two-wall defects. They summarized their results with the following formulation: "The degree of regeneration in

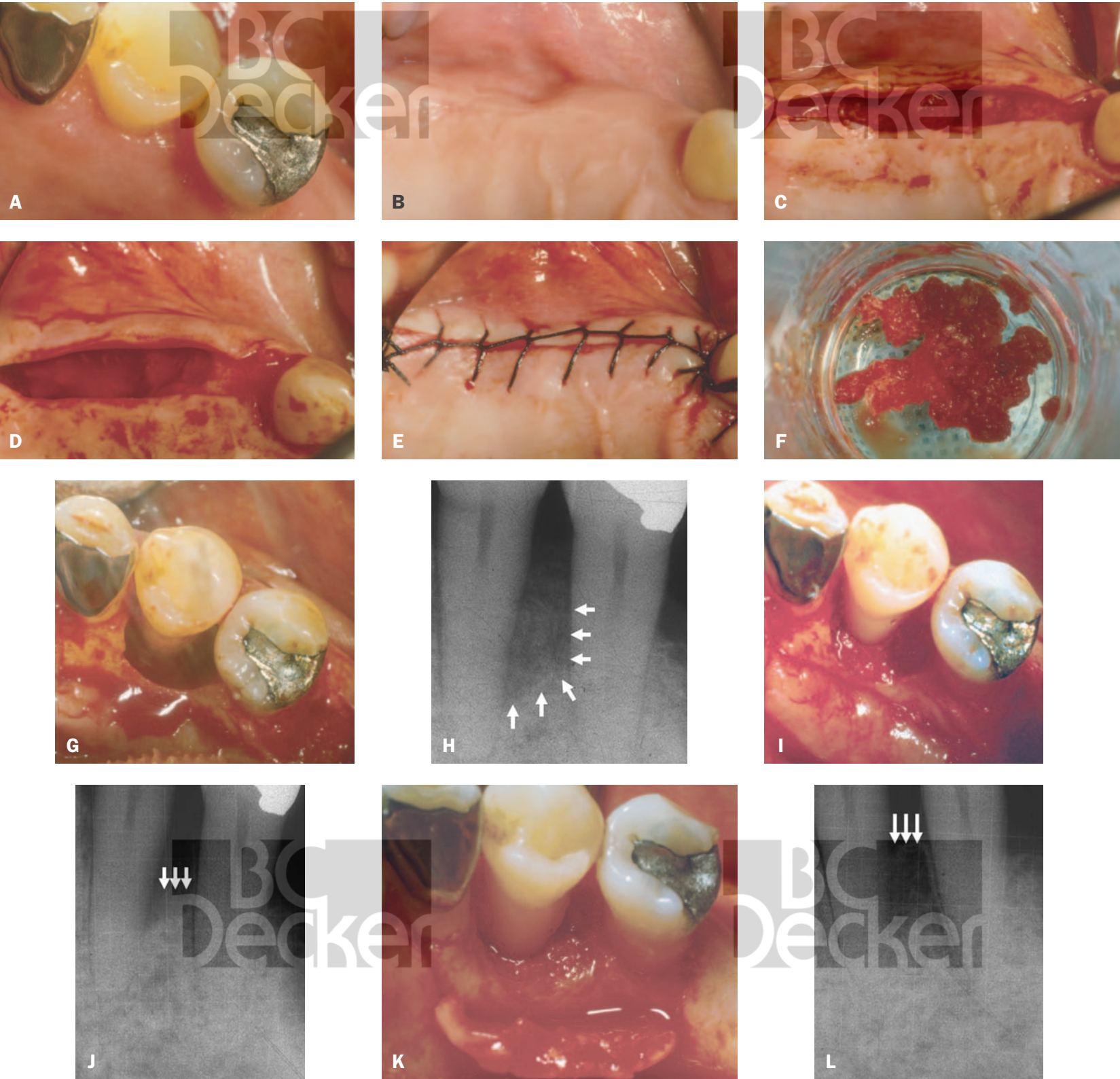


FIGURE 10-12. Autogenous tuberosity bone implant. A, Before treatment. B, Maxillary edentulous ridge and tuberosity. C, Mucoperiosteal flaps reflected. D, Autogenous cancellous bone removed. E, Ridge and tuberosity sutured. F, Cancellous bone placed in a sterile container. G, Lingual flap reflected and deep intraosseous defect visualized. H, Pretreatment radiograph study. I, Autogenous cancellous bone placed. J, Radiograph study done at the time of graft placement. K, Reentry 6 months later showing bone regeneration. L, Radiograph study showing bone regeneration.

an osseous defect...varies directly with the adequacy of the soft tissue coverage and with the surface area of the vascularized bony wall lining the defect; it varies inversely with the root surface area.”

Extraction Sites. Halliday (1969), in an attempt to provide adequate procurement of autogenous cancellous bone, developed a two-stage surgical procedure. The technique used a bone trephine to create artificial defects in the mandible; 6 or 7 weeks later, the area was reentered, and the new

bone was removed and transplanted to the intraosseous defect.

The concept of using newly formed bone from artificial defects has been extended to include bone from extraction sites. If extractions are required, they are timed to coincide with treatment of the intraosseous defects so that reentry can take place 6 to 8 weeks later (Figure 10-14).

BONE SWAGING. Ewen (1965) introduced the contiguous or bone swaging technique for treating bony defects, in which bone from an edentulous

area was moved next to the tooth to get rid of the defect. This required that the bone be fractured, without completely severing it to maintain the blood supply, and at the same time be moved next to the tooth (Nabers and O’Leary, 1967).

For practical purposes, this is a difficult, impractical technique, the results of which have not been borne out by research. It is further limited by the need for an adjacent edentulous ridge and bone quality that permits bending without fracturing.



FIGURE 10-13. Bone trephine utilized for autogenous bone graft. A, Flaps reflected showing intrabony defect. B, Blue trephine in position. C, Trephine removed. D, Cortical and cancellous bone collected. E, Defect filled.

Alloplasts—Ceramics. Ceramic materials, although convenient, readily available, and economical, have not been shown to function in any capacity other than that of an inert space filler. They have no significant osteoinductive capacity but have been shown to have some osteoconductive capacity (porous hydroxyapatite) (Louise, 1992). They serve well as biologic expanders, (tricalcium phosphate [TCP]) when sufficient autogenous bone is unavailable (Figure 10-15).

In a series of studies comparing FDBA, DFDBA, and porous hydroxyapatite (Interpore) in intrabony defects (Oreamuno and colleagues, 1980; Kennedy and colleagues, 1985, 1988; Barnett and colleagues, 1989; Bowen and colleagues, 1989), no significant differences in probing attachment levels and probing bone levels were

found. Egelbert (1992), in reviewing their results, found that one of two defects had a gain of 2 mm or more in bone and one of three defects had a gain of 3 mm or more in bone.

Kennedy and colleagues (1988), using porous hydroxyapatite (Interpore 200) in Class II furcations on mandibular teeth, found significant gains in attachment levels (1.82 mm; $p \leq .00010$) and bone fill. Corsair (1990) obtained 51% fill of intrabony defects with a resorbable hydroxyapatite (OsteoGen® Implant Ltd. Holliswood, New York) with a predictable controlled resorption rate. In his 5-year evaluation of durapalite (Periograft), Yukna (1980) found that grafted sites improved or stayed the same 86% of the time compared with only 62% for débridement and that 38%, or three times as many, of the débrided

areas failed as opposed to hydroxyapatite-grafted sites. Yukna (1990), in analyzing the results using a synthetic (HTR) polymer, found that 71% of the participants had an overall positive ($\geq 50\%$) response compared with only 24% for the control sites, which had flap débridement alone. Shahmiri (1992), on the other hand, found no significant differences between the control and HTR-treated intrabony sites.

Saffar and colleagues (1990), in biopsies of human intrabony defects, found that TCP was progressively modified and resorbed and eventually replaced by bone. They concluded that TCP has osteogenic potential (see Figure 10-15). Pepelassi and colleagues (1991), using a combination of doxycycline-TCP and sterile plaster of Paris found that there was a three to seven times



FIGURE 10-14. Autogenous bone implant from an extraction site. A, Mucoperiosteal flap preparation. B, Buccal view of an angular intraosseous defect. C, Lingual view of the same circumferential defect. D, Autogenous bone taken 8 to 10 weeks after tooth extraction. E, Graft placed at or slightly above the crest of the defect. F, Preoperative (left) and postoperative 6-month radiograph studies. Note osseous regeneration (arrows). G and H, Buccal and lingual views at the time of reentry showing bone regeneration. Compare with B and C. Originally contributed by Edward S. Cohen, DMD, to Glickman's *Periodontology* and reproduced with permission from W.B. Saunders.



FIGURE 10-15. Calcium sulfate for regeneration. A, Before, with 10 mm probing. B, Intrabony defect probing, 13 mm. C, Demineralized freeze-dried bone allograft placed. D, Sterile-grade medical calcium sulfate used as a membrane. E, Ten months later; 3 mm sulcus depth. F, Reentry 10 months later; complete bone fill.

with a likelihood of 50% as greater defect fill in Class II furcations when compared with the non-grafted controls. Class III furcation showed even more pronounced changes.

It is important to note that, histologically, healing is by a long junctional epithelium (repair) with the hydroxyapatite, hydroxylapatite, durapatite, and HTR being well tolerated but surrounded by encapsulated connective tissue.

Allografts. *Demineralized Freeze-Dried Bone Allografts.* Urist (1965, 1968, 1971, 1980) showed the inductive capabilities of DFDBAs. He and his colleagues isolated a bone morphogenetic protein

(BMP) that is capable of osteogenic induction by inducing primordial cells to differentiate into osteoblasts. Demineralization exposes the collagen matrix that harbors the inductive proteins (BMP), thereby permitting greater inductability. The ideal particle size is between 250 and 500 μm . This small size permits

1. High inductive potential
2. Easy resorption and replacement
3. Increased surface area for primordial mesenchymal cell interaction

Particles smaller than 250 μm are absorbed quickly, and the larger ones are inadequately used.

DFDBA meets all of the criteria for the ideal grafting material (Table 10-2):

1. Availability
2. Predictability
3. Biocompatibility
4. Osteoinductivity
5. Osteoconductivity
6. Cost-effectiveness
7. Safety

Mellonig (1984) achieved significant bone regeneration using the DFDBA. He showed a 64.7% increase with DFDBA as opposed to 37.8% for the controls ($p < .01$). Furthermore, his results

Table 10-2 Criteria for an Ideal Implant Material					
	Bone Marrow	Intraoral Bone	DFDBA	Bio-Oss	Alloplasts
Osteoinductive	+++	+	++	—	—
Osteoconductive	+++	++	++	++	+
Immediately osteogenetic	+++	+	++	—	—
New cementum induction	+++	+	++	++	—
Safety	+	+++	+++	+++	+++
Stability to remain in position	+++	+	++	+++	++
Replacement	+++	+++	++	+++	†
Adequate supply	++	+++	++++	+++	
DFDBA = demineralized freeze-dried bone allograft.					
*Bio-Oss Collagen.					
†See Table 10-3.					

showed a 78% fill for all types of intrabony defects, with 90% for two-wall defects. Bowers and colleagues (1985), in a preliminary report, showed that DFDBA is capable of producing not only bone fill in intrabony defects but also new attachment, both clinically and histologically. Bowers (1989a, 1989b) completed this histologic evaluation of new attachment using DFDBA in 32 grafted versus 25 nongrafted sites (Figure 10-16). The DFDBA group showed significantly greater new attachment ($p < .005$), new cementum ($p < .005$), new connective tissue ($p < .05$),

and new bone ($p < .001$) in intrabony defects grafted with DFDBA than in nongrafted sites. Nongrafted defects showed no new cementum or periodontal ligament regeneration. Laurell and colleagues (1998), in a meta-analysis review of 21 trials (512 intrabony defects), found the following:

- 1. DFDBA significantly enhanced bone fill when compared with OFD without bone grafts (2.2 vs 1.1 mm).
- 2. The average fill was 1.2 mm for OFD and

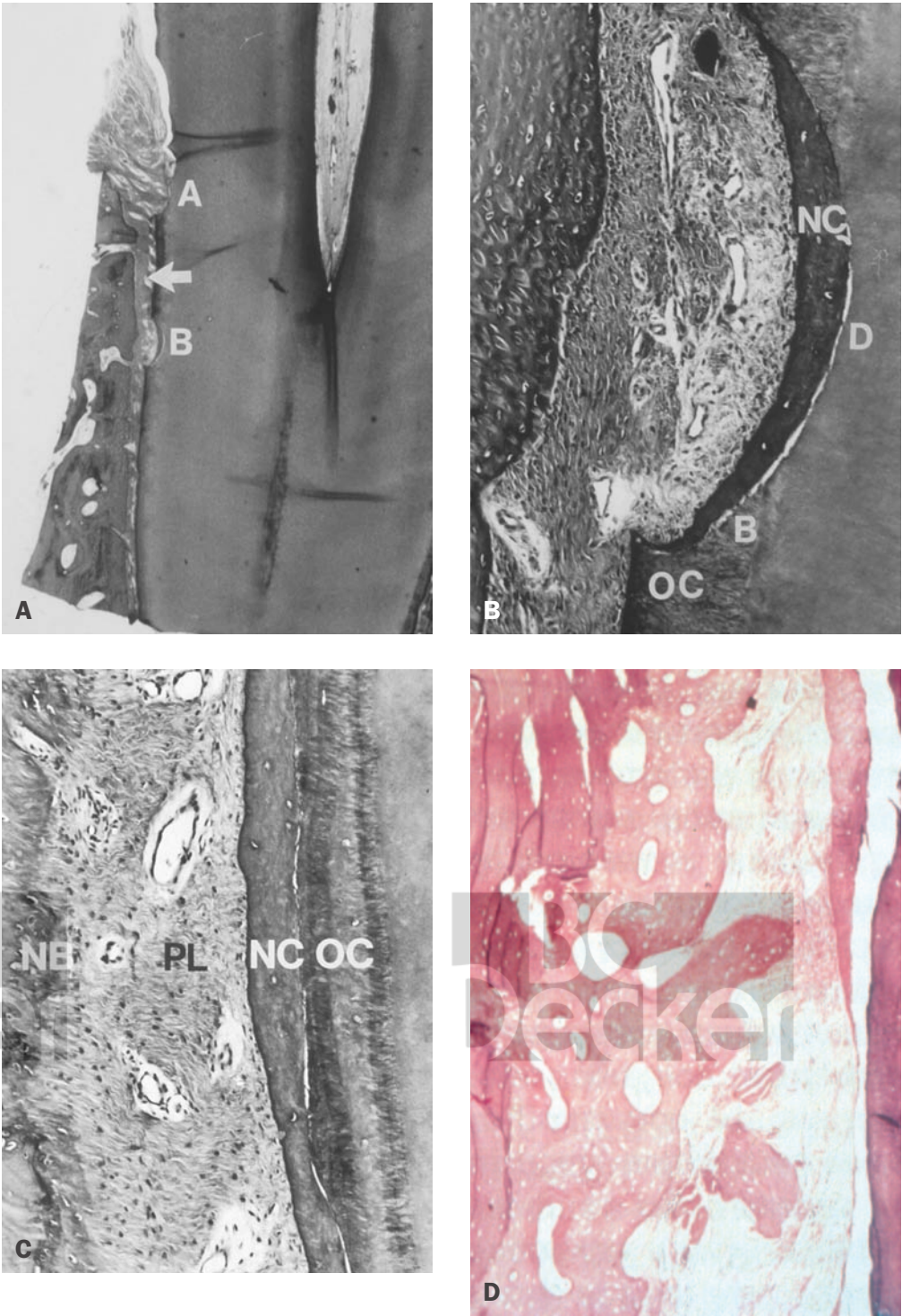
2.3 mm for OFD + DFDBA, irrespective of defect configuration.

- 3. In comparing the percentage of cases achieving CAL-G and bone fill of ≥ 2 mm, they found:

	CAL-G %	Bone Fill %
OFD+ DFDBA	49	38.7
OFD + DFDBA	66	61.2

- 4. Defects of 4 to 5 mm have a greater percentage of bone fill on average than deeper defects (≥ 6 mm) even though deeper defects have the potential for the largest amount of bone fill.

FIGURE 10-16. A, Grafted defect demonstrating new attachment apparatus formation from calculus reference notch B to reference notch A. New cementum formed over both dentin and old cementum. The junctional epithelium is located approximately level with the alveolar crest at reference notch A (hematoxylin-eosin stain; $\times 4$ original magnification). B, Higher magnification of calculus notch B in A demonstrating the formation of a new attachment apparatus. Note that new cellular cementum (NC) has formed over old cementum (OC) and over dentin (D). Periodontal ligament fibers appear to be oriented both parallel and perpendicular at this level (hematoxylin-eosin stain; $\times 40$ original magnification). C, Higher magnification of the region of the arrow in A. Note new cellular cementum formation (NC) over old cementum (OC). Also note the perpendicular arrangement of periodontal ligament fibers (PL) at this level (hematoxylin-eosin stain; $\times 40$ original magnification). Courtesy of Gerald M. Bowers, Baltimore, MD.



Note: Schwartz and colleagues (1996), Becker (1995), and Garraway and colleagues (1998) demonstrated that the residual BMPs in DFDBA were in lower quantity than fresh bone and varied with donor age and bone bank. This may explain the variability in the results obtained. The clinical results can be seen in Figures 10-17 to 10-22.

Freeze-Dried Bone Allografts. FDBA, a material readily obtainable from various bone banks, has been shown to be osteoconductive. When FDBA is combined with an ABG, it may become osteoinductive (Saunders and colleagues, 1983).

Sepe and colleagues (1978) and Mellonig (1980, 1981) showed that you can achieve a 50% or greater bone fill in various types of defects 60% of the time. More recently, Saunders and colleagues (1983) showed that when FDBA is combined with ABG, there is an 80% chance of achieving 50% or greater bone fill in all defects.

Yukna and Sepe (1982) used a combination of tetracycline and FDBA in a 4:1 ratio in 62 defects and were able to achieve complete fill in 22 sites, greater than 50% in 39 sites, and less than 50% in only 1 site. These results appear to be better than those when FDBA is used alone.

Yukna and Vastardis (2005) demonstrated histologically in vitro (monkey) FDBA to be significantly more osteoconductive and osteoinductive than DFDBA. They concluded that “FDBA may stimulate earlier, more rapid, and larger quantities of new bone formations than DFDBA.”

This is consistent with the results of Plattelli and Scarano (1996) and Paul and colleagues (2001), who found similar histologic results in humans. Rummeltart (1989) demonstrated no difference in bone fill between FDBA and DFDBA.

Note: DFDBA is the accepted and proven allographic material of choice for human regeneration in intrabony defects and furcations.

FDBA, being readily available, appears to be an ideal material for use as a biologic expander when ABG material alone is insufficient (Figure 10-23).

Bone Substitutes. Today nonautogenous and nonallograft materials have gained wide acceptance as regeneration materials (World Workshop in Periodontics, 1996). Gross (1997) outlined the ideal characteristics for bone substitute grafts:

1. Biocompatibility
2. Serve as a scaffold (framework) for new bone formation
3. Resorbable in the long term and have the potential for replacement by host bone
4. Osteogenic, or at least facilitate new bone formation
5. Radiopaque
6. Easy to manipulate
7. Do not support growth or oral pathogens
8. Hydrophilic (to attract and hold the clot in a particular area)

9. Available in particulate and molder forms
10. Microporous (for added strength to the regenerating host bone matrix; allow biologic fixation)
11. Availability
12. Nonallergenic
13. Have a surface that is amenable to grafting
14. Act as a matrix or vehicle for other materials (ie, bone protein inducers, antibiotics)
15. Have high compressive strength
16. Are effective in GTR procedures

Alloplasts—Ceramics. Ceramic materials, although convenient, readily available, and economical, have not been shown to function in any capacity other than that of an inert space filler. They have no significant osteoinductive capacity but have been shown to have some osteoconductive capacity (porous hydroxyapatite) (Louise, 1992). They serve well as biologic expanders (TCP) when sufficient autogenous bone is unavailable (see Figure 10-15).

The World Workshop in Periodontics (1996), the *Annals of Periodontology* (2003), and the AAP position paper on periodontal regeneration (2005) concluded that *synthetic graft materials or alloplasts function predominantly as biologic space fillers and that other materials should be considered if regeneration is desired*. These materials are well tolerated, and healing is by repair (long junctional epithelium).

Reynolds and colleagues (2003) further stated that “the results of these controlled studies

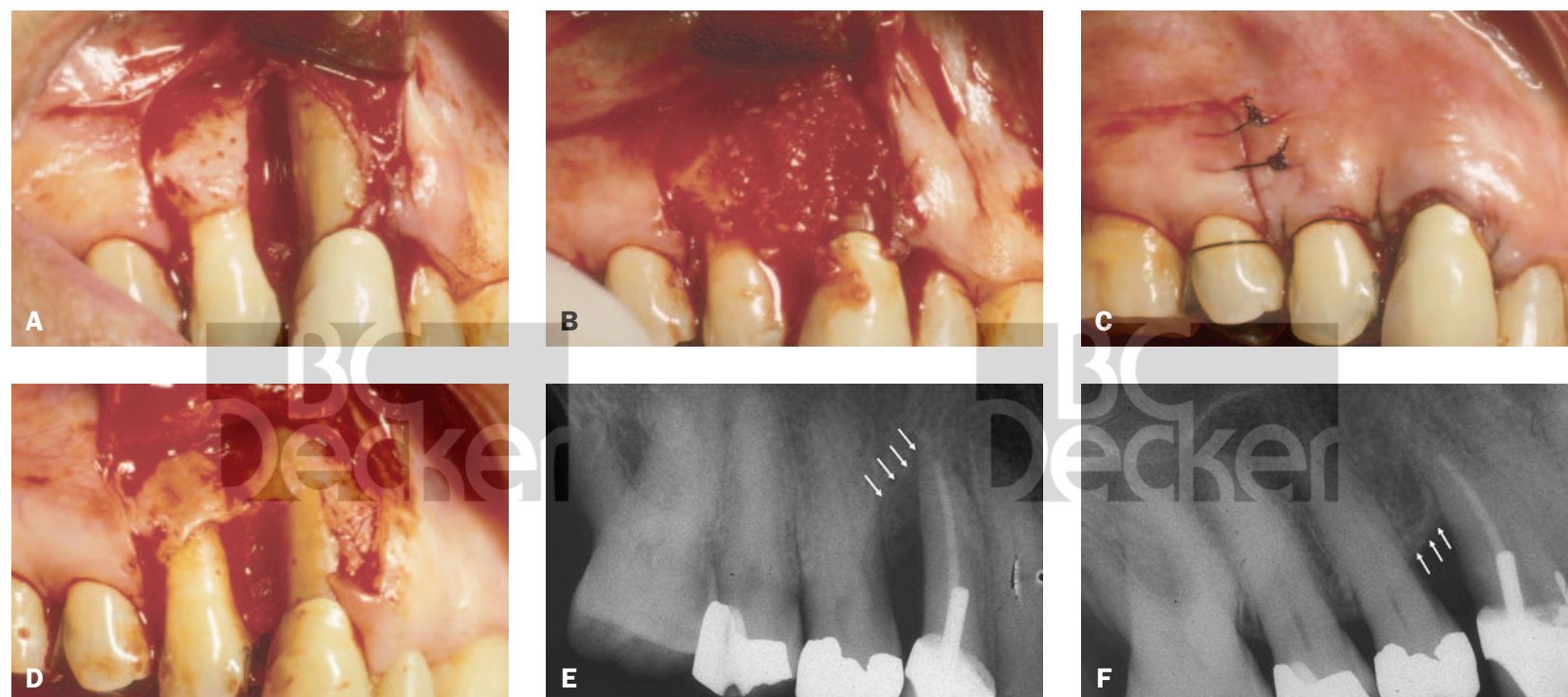


FIGURE 10-17. Demineralized freeze-dried bone allograft (DFDBA). A, Initial view of a defect: two-wall defect with buccal dehiscence. B, DFDBA placed. C, Flaps sutured. D, Reentry 1 year later. Note significant bone increases compared with A. E, Radiograph study taken before surgery. F, Radiograph study taken at the time of reentry.

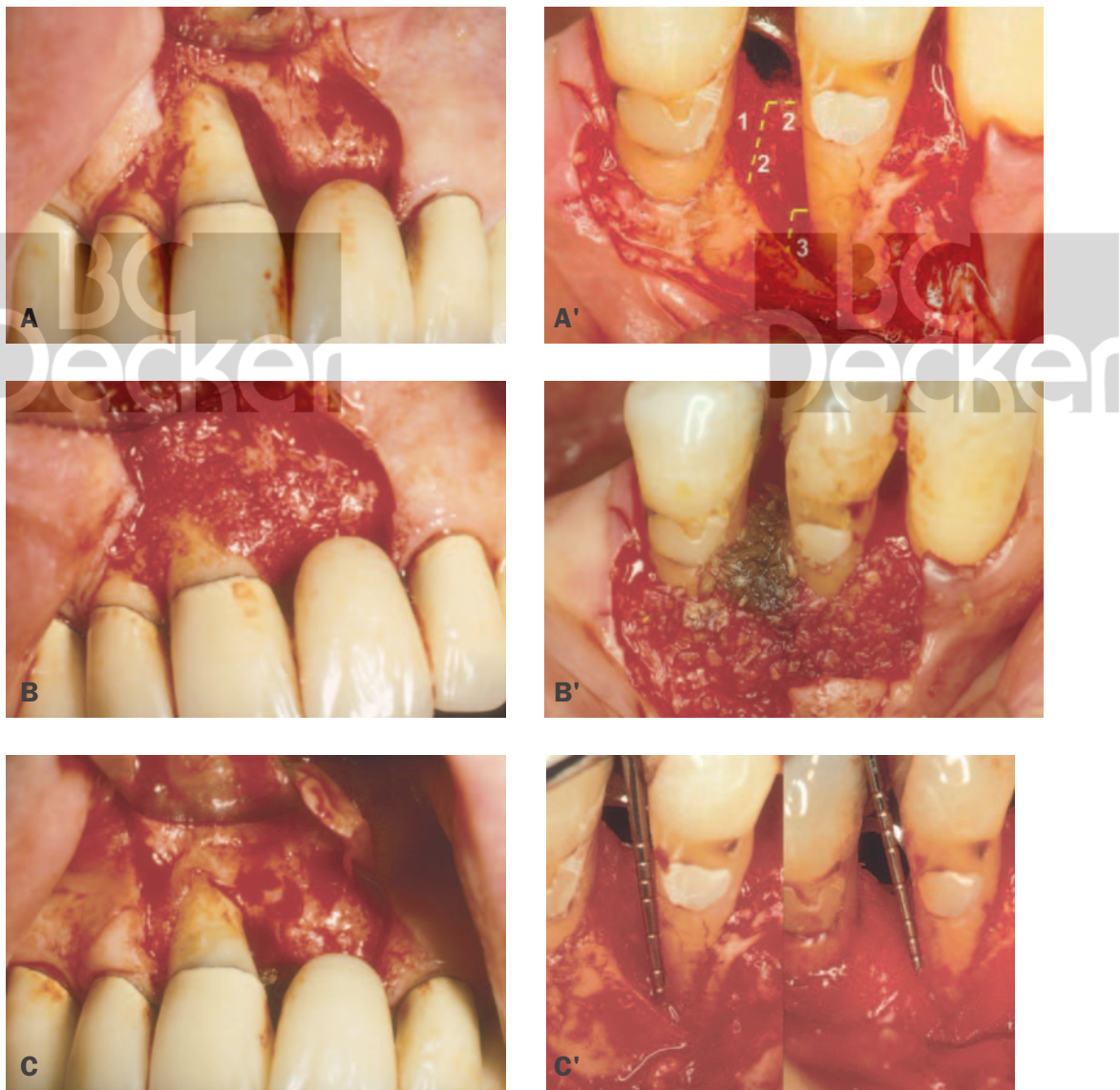


FIGURE 10-18. Demineralized freeze-dried bone allograft (DFDBA) on two different central incisors. A and A', Defects exposed. B and B', DFDBA placed. Note placement of graft material over the exposed root surface. C and C', Reentry after 1 year. Note defect fill and some coverage of root dehiscences.

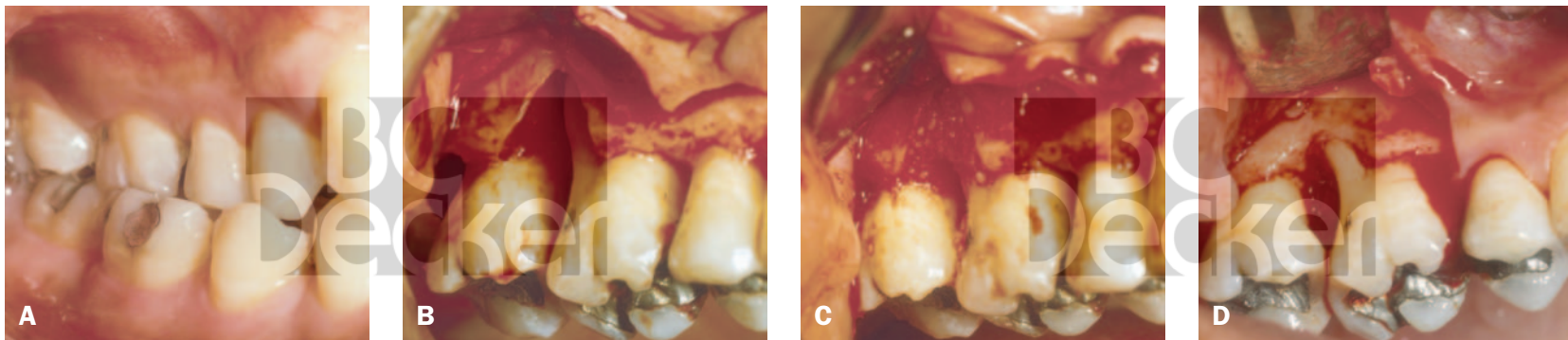


FIGURE 10-19. Demineralized freeze-dried bone allograft (DFDBA). A, Before surgery. B, Defect exposed. Note loss of the buccal plate, distobuccal root dehiscence, and interproximal defect. C, DFDBA placed. D, Reentry after 1 year. Note bone regeneration (compare with B).

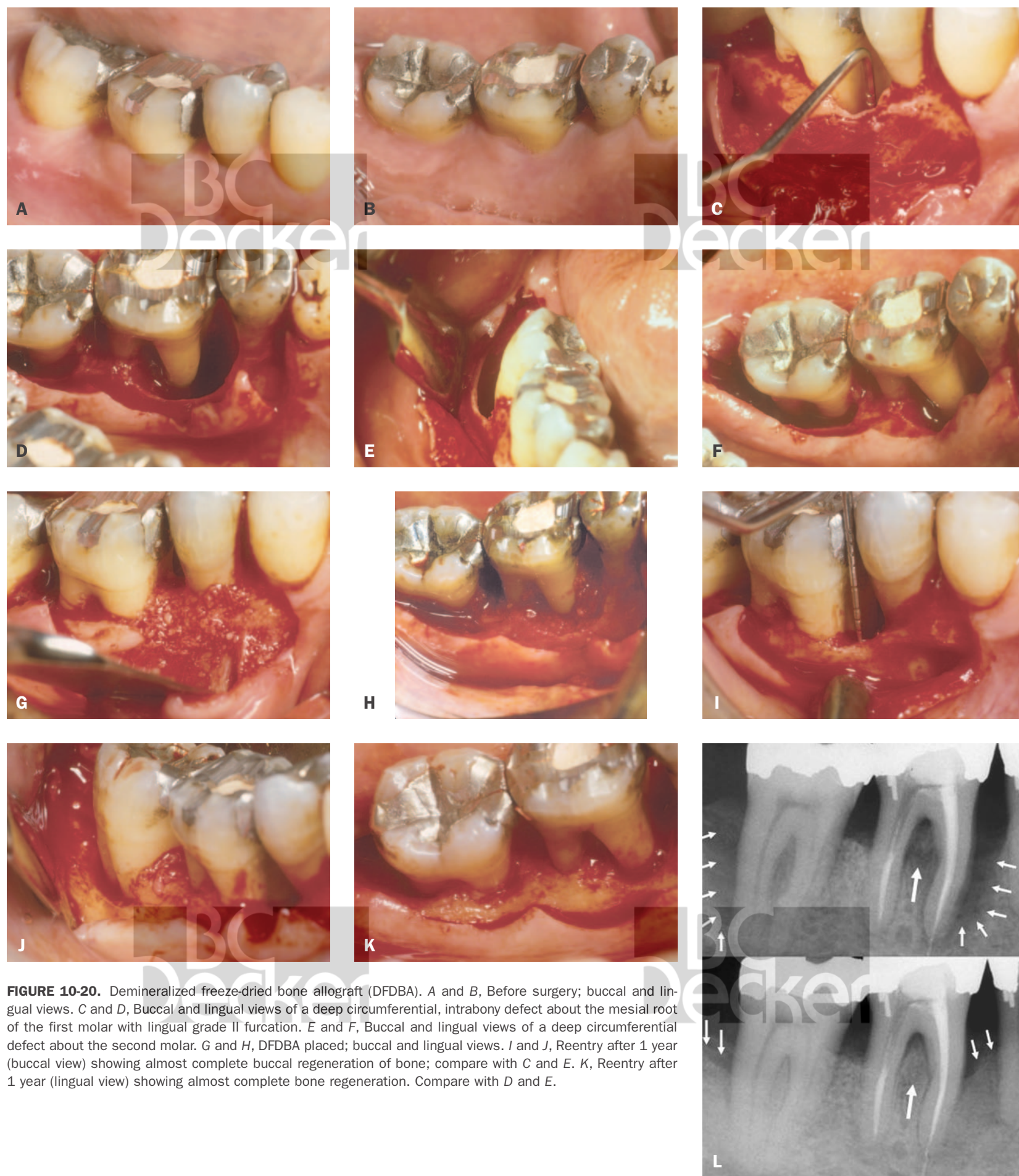




FIGURE 10-21. Periodontal orthodontic treatment for correction of an infrabony defect and unsightly spacing. *A*, Before. *B*, Two- to three-wall intrabony defect. *C*, Demineralized freeze-dried bone allograft placed in the defect. *D*, Flap sutured. Note that a modified flap was raised from the palate for papillary preservation. *E*, Final case 4 years later with minimal papillary loss. *F*, Orthodontics for space closure and papillary restoration between teeth no. 8 and 9. Teeth no. 8 and 9 are also being intruded. *G*, Final case 9 1/2 years later with full papillary restoration. *H*, Radiographic findings: before, 5 years later, and at the completion of orthodontics. Note the ideal contour of the interproximal bone.



FIGURE 10-22. Modified papillary surgical procedure for treatment of the esthetic zone. *A*, Before view of buccal and *B*, palatal aspects. *C*, Two- to three-wall intrabony defect. *D*, Demineralized freeze-dried bone allograft. *E*, Flap sutured; buccal and *F*, palatal views. *G*, Final case (10 months). Note minimal tissue shrinkage. *H*, Before and after radiographic images.

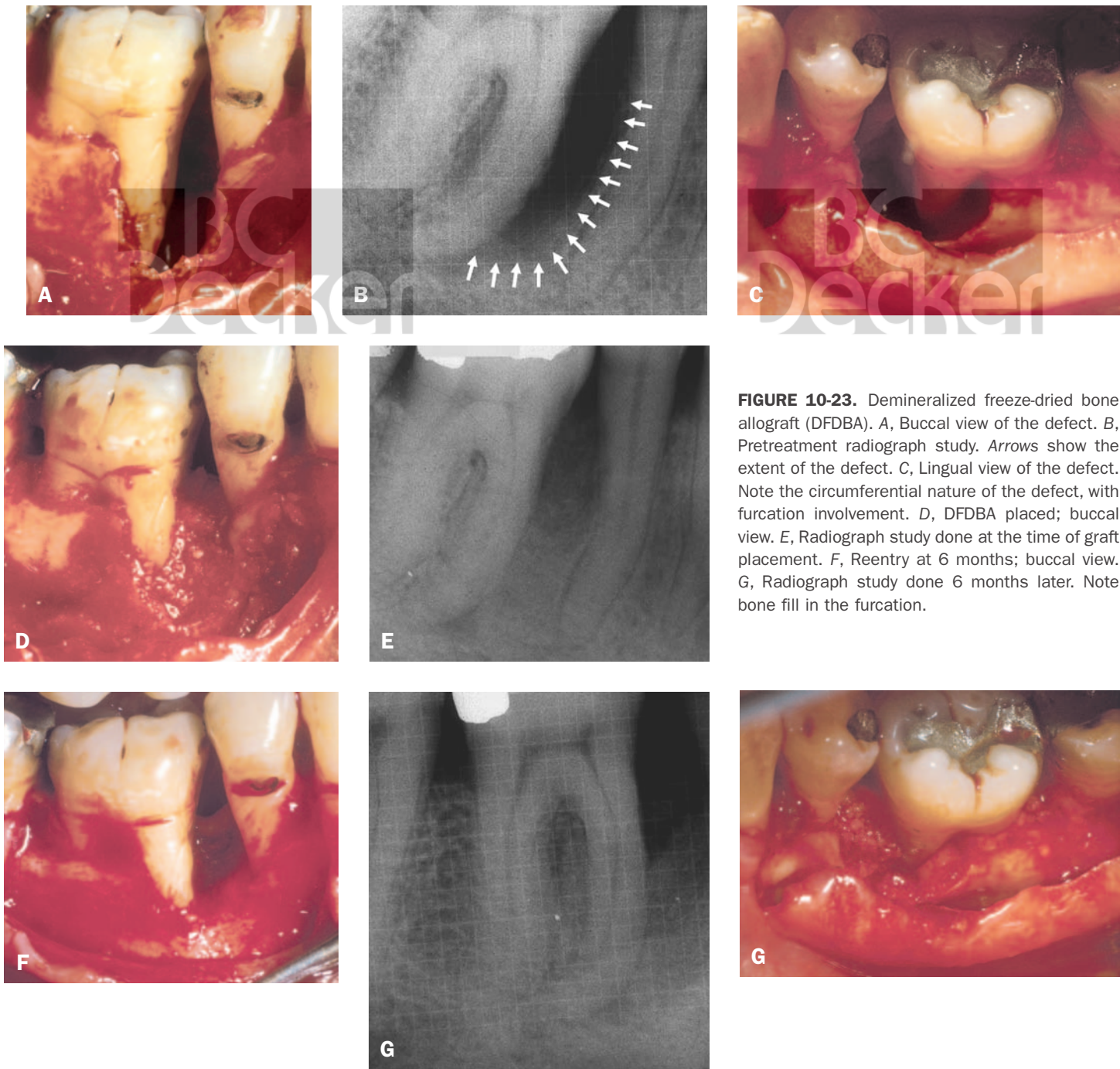


FIGURE 10-23. Demineralized freeze-dried bone allograft (DFDBA). *A*, Buccal view of the defect. *B*, Pretreatment radiograph study. Arrows show the extent of the defect. *C*, Lingual view of the defect. Note the circumferential nature of the defect, with furcation involvement. *D*, DFDBA placed; buccal view. *E*, Radiograph study done at the time of graft placement. *F*, Reentry at 6 months; buccal view. *G*, Radiograph study done 6 months later. Note bone fill in the furcation.

provide strong evidence that Bone Replacement Grafts (BRGs) provide superior clinical outcomes than open flap debridement (OFD) procedures in the treatment of intrabony defects.”

Author's Note: It is strongly recommended that the reader review the *Annals of Periodontology* (2003) and the AAP position paper on periodontal regeneration (2005) for a complete review of the subject.

Treatment of Periodontal Furcations with Coronally Positioned Flaps and CA. Conventional periodontal therapy has often met with limited success in treating Class II and III furcation lesions. Martin and colleagues (1988), Gantes and colleagues (1988, 1991), and Garrett and colleagues (1990) devised a surgical procedure that was designed to gain adequate wound closure and clot stabilization. The technique uses CA for contact inhibition of epithelial downgrowth and a coronally positioned flap for wound closure and clot retention. Stahl and Froum (1991) recently confirmed histologically the ability to achieve new attachment using this technique.

This technique has provided one of the most successful bone fill results of Class II furcations. In separate studies (Martin and colleagues 1988, Garrett and colleagues 1990), it was found that an average of 67 to 70% bone fill by volume, with 43 to 56% displaying 100% bone fill. The results were not enhanced by use of DFDBA or restorable membranes (collagen or dura mater). Bone fill results in Class III furcation were limited to only 15%.

It is important to note that these favorable results do not carry over to treatment of intrabony defects. Egelberg (1992), in reviewing a series of studies comparing intrabony defects with and without CA (Renvert and colleagues, 1981, 1985a, 1985c; Chamberlin, 1985) and CA versus osseous grafting (Renvert and colleagues, 1985b), found no significant differences in probing attachment level (1.1–2.0 mm) or probing bone levels (0.6–1.3 mm).

Indications.

1. Class II or Class III furcations
2. Class II maxillary, buccal furcations

Advantages.

1. Simple
2. Predictable
3. Cost-effective

Disadvantage. Complicated suturing for coronal flap position

Procedure.

1. An orthodontic bracket or tube is cemented to the buccal or lingual surface above the furcation to be treated (Figure 10-24A)
2. Vertical incisions are made on the mesial and distal aspects of the tooth dissecting the interdental papilla. Each incision is approxi-

mately 15 mm in length and made down to bone (Figure 10-24B).

5. An intrasulcular incision is now made joining the two vertical incisions (Figure 10-24B).
6. Upon reflection of a mucoperiosteal flap, the exposed roots are scaled and root planed with hand and ultrasonic scalers and all granulation tissue is removed. Enamel projections are removed with high-speed pear-shaped finishing burs (Figure 10-24C).
7. Osseous surgery is not performed.

8. The apical portion of the mucoperiosteal flap is fenestrated to permit coronal positioning (Figure 10-24D).
9. A saturated solution of citric acid (pH1.0) is applied with cotton pellets for 3 minutes, followed by saline irrigation (Figure 10-24E).
10. Bleeding in the furcation is stimulated by scratching the periodontal ligament with an explorer.
11. The authors recommend the following suturing techniques to assure flap place-

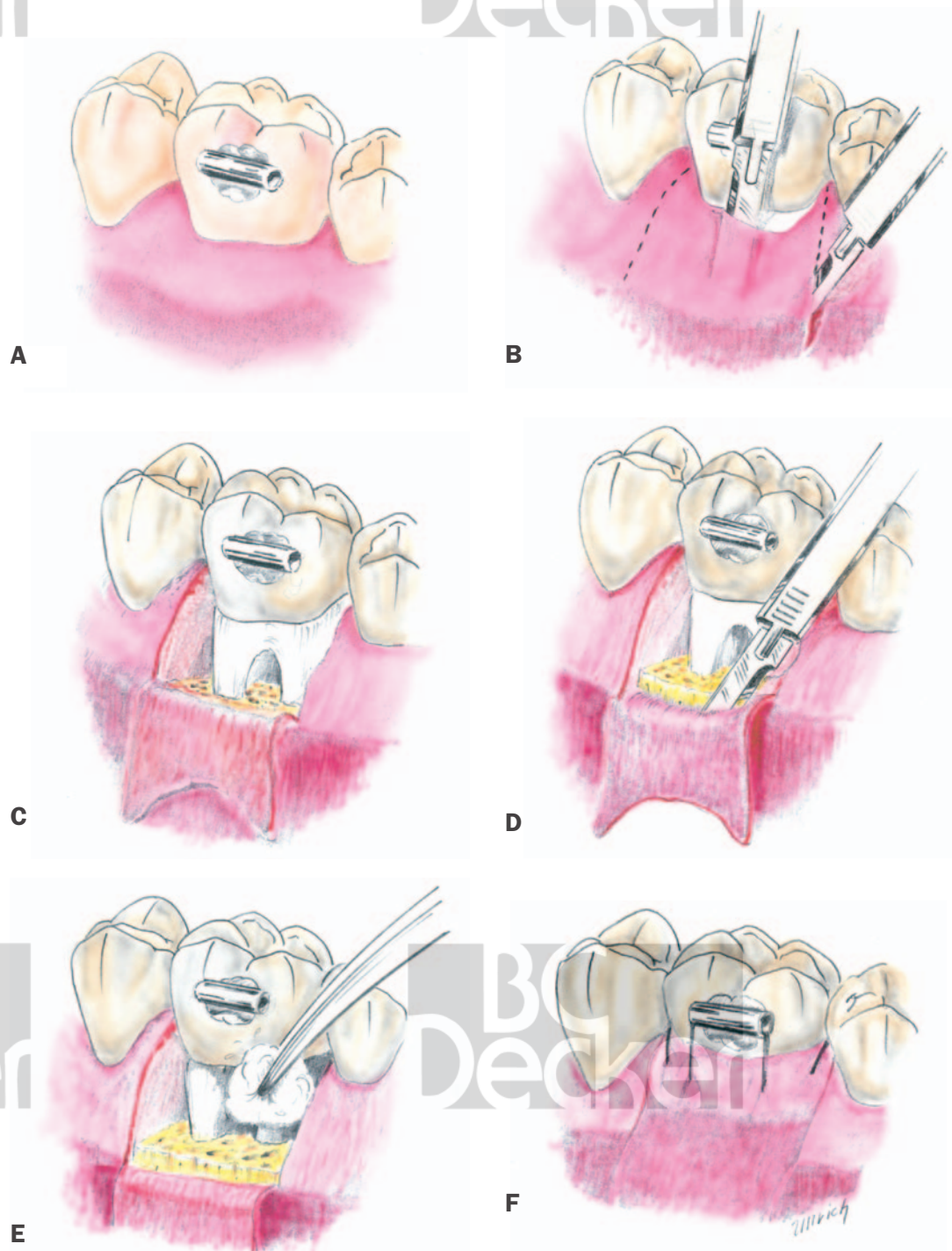


FIGURE 10-24. Citric acid and coronally positioned flaps. A, Before treatment, with incisions outlined. B, Vertical and sulcular incisions being made. C, Flap reflected with furcation exposed. D, Apical periosteal fenestration for flap release for coronal positioning. E, Citric acid application (pH 1.0 for 3 minutes). F, Flap coronally positioned and sutured.

- ment. A 4-0 silk suture is passed through the tube starting from the mesial aspect; the suture is continued with a horizontal mattress in the distal part of the flap margin; subsequently the suture is passed interdentally on the distal aspect of the tooth, swing around the tooth, passed interdentally on the mesial aspect of the tooth, followed by a horizontal mattress in the mesial flap margin; the suture is tied with the flap margin in a coronal position and with a tight apposition of the flap over the entire mediobuccal extension of the crown (Figure 10-24F).
12. Tetracycline ointment (aureomycin 3%) is placed over the flap margins. A periodontal dressing is not placed.
 13. The patient is placed on tetracycline 250 mg for 2 weeks. One week later the dressing is removed, the area debrided, tetracycline ointment reapplied, and the area repacked. The sutures and dressings are removed in 2 weeks. The clinical procedure is depicted in Figure 10-25.

The WWP (1996) found that coronally positioned flaps with CA are associated with better clinical outcomes in furcation defects than open flap surgery. It is generally agreed (Murphy and Gunsolly, 2003; Reynolds and colleagues, 2003, AAP Position Paper on Periodontal Regeneration, 2005) that although CA does provide significant human regeneration, clinically, the results are not significant.

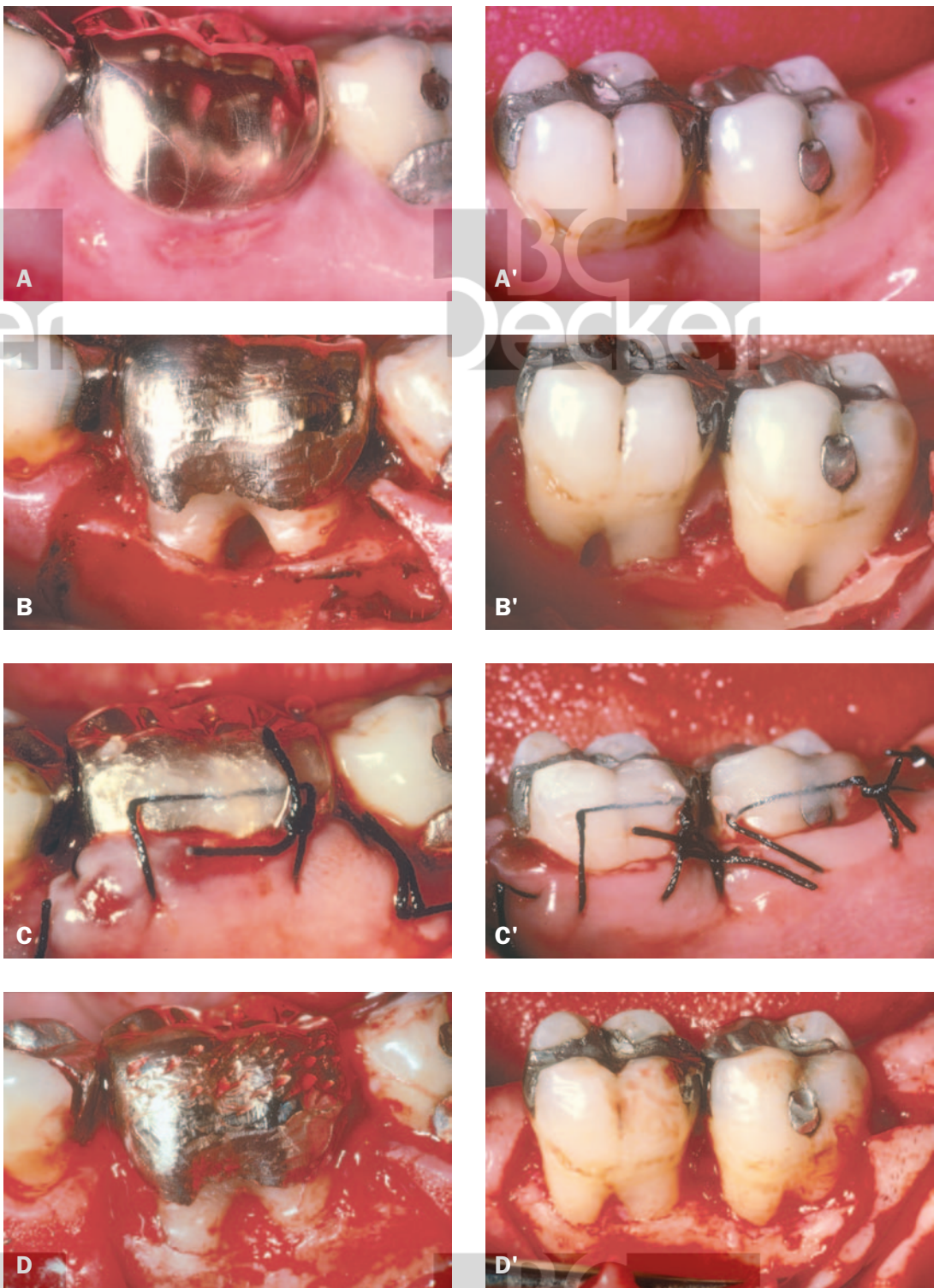


FIGURE 10-25. Citric acid and coronally positioned flaps. A, Before surgery. B, Grade II furcations exposed. C, Flaps sutured coronally. D, One year after surgery. D', Reentry after 1 year with complete bone regeneration; compare with B. Courtesy of Dr. Bernard Gantes.

Xenograft (Bio-Oss)

A xenograft (heterograph) is a graft taken from another species (AAP, 2001). Bio-Oss is a purified bovine-derived xenograft (BDX). Its crystalline calcium-carbonate mineralized apatite matrix is derived by a low-heat (300°C) chemical extraction process. The extraction process removes all of the organic components while maintaining the exact porosity, size, and trabecular architecture of bone. This is unlike OsteoGraft, which uses a high-heat (1,100°C) extraction process, fusing the bone crystallites and producing a large non-homogeneous crystal morphology with decreased porosity and surface area (Gross, 1997). Bio-Oss Collagen is identical to Bio-Oss except that an additional 10% of purified porcine collagen has been added. Nu-Oss (Ace Surgical Supply, Brockton, Massachusetts) although almost identical to Bio-Oss in physical and chemical structure has not been shown to be capable of periodontal regeneration at this time.

Advantages

1. Unlimited supply
2. Safe
3. Biocompatible
4. Nonantigenic
5. Permits physiologic vascular ingrowth
6. Permits complete integration and incorporation into bone
7. Possesses the same structure as bone:
 - a. Compact appetite crystalline structure
 - b. Large inner surface area
 - c. Porosity similar to that of human cancellous bone

A number of studies have demonstrated the ability of BDX to show gains in clinical attachment levels and bone fill (Cohen and colleagues, 1990; Brion, 1991; Clergeau and colleagues, 1996). Richardson and colleagues (1999) compared DFDBA with BDX, and although they found no statistical differences, there was a strong tendency favoring the BDX over the DFDBA. Schwartz and colleagues (1998) studied the effect of what they believed to be residually retained protein in the BDX matrix and found these protein to be osteoinductive. They concluded that “the results of the present study indicate that the deproteinized cancellous bovine bone particles examined contain residual proteins and that at least some of

these proteins are bioactive factors like [transforming growth factor β] and BMP-2.” However, Benke and colleagues (2001), in an independent study, found no evidence of residual protein within the BDX matrix, including transforming growth factor β . Further, in a second independent study, Wenz and colleagues (2001) concluded that “based on the results of the determination of total amount of protein and 4-hydroxyprolin there is no evidence of the protein in Bio-Oss.”

As previously noted, clinical evidence of bone fill and defect resolution does not infer and is not synonymous with regeneration (new bone, new cementum, a new periodontal ligament). *Regeneration is a histologic finding.* In studies by Mellonig (2000) and Camelo and colleagues (1998), some histologic evidence of regeneration was shown when BDX was combined with an autogenous graft and collagen barrier membrane (Bio-Gide, Osteohealth) and a significant amount of periodontal regeneration was obtained.

Recently, Nevins and colleagues (2003) histologically studied the ability of Bio-Oss Collagen (Osteohealth) with and without a collagen membrane (Bio-Guide, Osteohealth, Uniondale, New York) to promote periodontal regeneration in intrabony defects in four cases. They were able to histologically demonstrate regeneration of a completely new attachment apparatus in all cases. Two of the four cases met the definition of regeneration as defined by the 1996 WWP. The results for the individual cases were 3.0, 1.9, 3.1, and 1.7 mm, respectively, for the completely new attachment apparatus, with a greater formation of new bone and new cementum in all cases (Figures 10-26 to 10-29).



FIGURE 10-26. Five-millimeter two-wall intrabony defect on the distal aspect of a mandibular right first premolar.



FIGURE 10-27. Distal aspect of first premolar treatment with Bio-Oss Collagen alone shows good restoration of a completely new attachment apparatus. Arrow = end of the junctional epithelium; boxes = positions of Figures 3c (top) and 3d (bottom) (toluidine blue–basic fuschin stain; $\times 10.5$ original magnification).

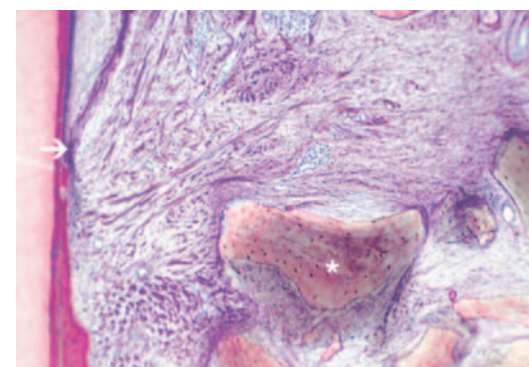


FIGURE 10-28. Epithelium is almost in touch with the coronal border or new cementum and new attachment (arrow). Most of the Bio-Oss granules layered over the defect are surrounded by connective tissue (*) (toluidine blue–basic fuschin stain; $\times 66$ original magnification).

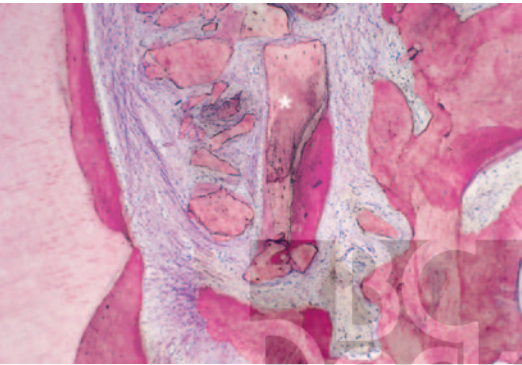


FIGURE 10-29. At the level of the upper border of the notch (arrowhead), the completely new attachment apparatus is fully resorbed. Bio-Oss is partially coated by new bone (*) (toluidine blue–basic fuschin stain; ×66 original magnification).

In a systematic meta-analysis review of the literature in the *Annals of Periodontology*, Reynolds and colleagues (2003) stated that “xenogenic bone grafts can support the formation of a new attachment apparatus [as opposed to] alloplastic grafts that support repair rather than regeneration.” This is consistent with the AAP position paper on periodontal regeneration (2005), which stated “that human histologic studies have reported periodontal regeneration in teeth treated with xenografts” and that alloplasts (synthetic bone substitute) function primarily as biocompatible space fillers.

See Figures 10-30 to 10-34 for successfully treated cases.

Table 10-3 lists a number of currently available alloplastic and xenograft grafting materials. Unfortunately, although some have shown clinical and histologic evidence of bone fill in periodontal defects, except for Bio-Oss and Bio-Oss Collagen, none have been able to show histologic evidence of regeneration (new bone, new cementum, and a new periodontal ligament on a previously diseased root surface). If regeneration is the “gold standard” we seek, then the only “presently” acceptably bone substitute material for treating periodontal defects is Bio-Oss. Bio-Oss is reportedly the most physiological bone substitute with eventual complete integration into bone (unlike hydroxyapatite or TCP) (Gross, 1977). Clinical examples of cases successfully treated with Bio-Oss are seen in Figures 10-30 to 10-34.



FIGURE 10-30. Guided tissue regeneration, Bio-Oss/BioGuide. A, Before. B, Defect. C, Bio-Oss placed. D, BioGuide positioned. E, Flap repositioned and sutured. F, Reentry 12 months later showing complete bone regeneration.

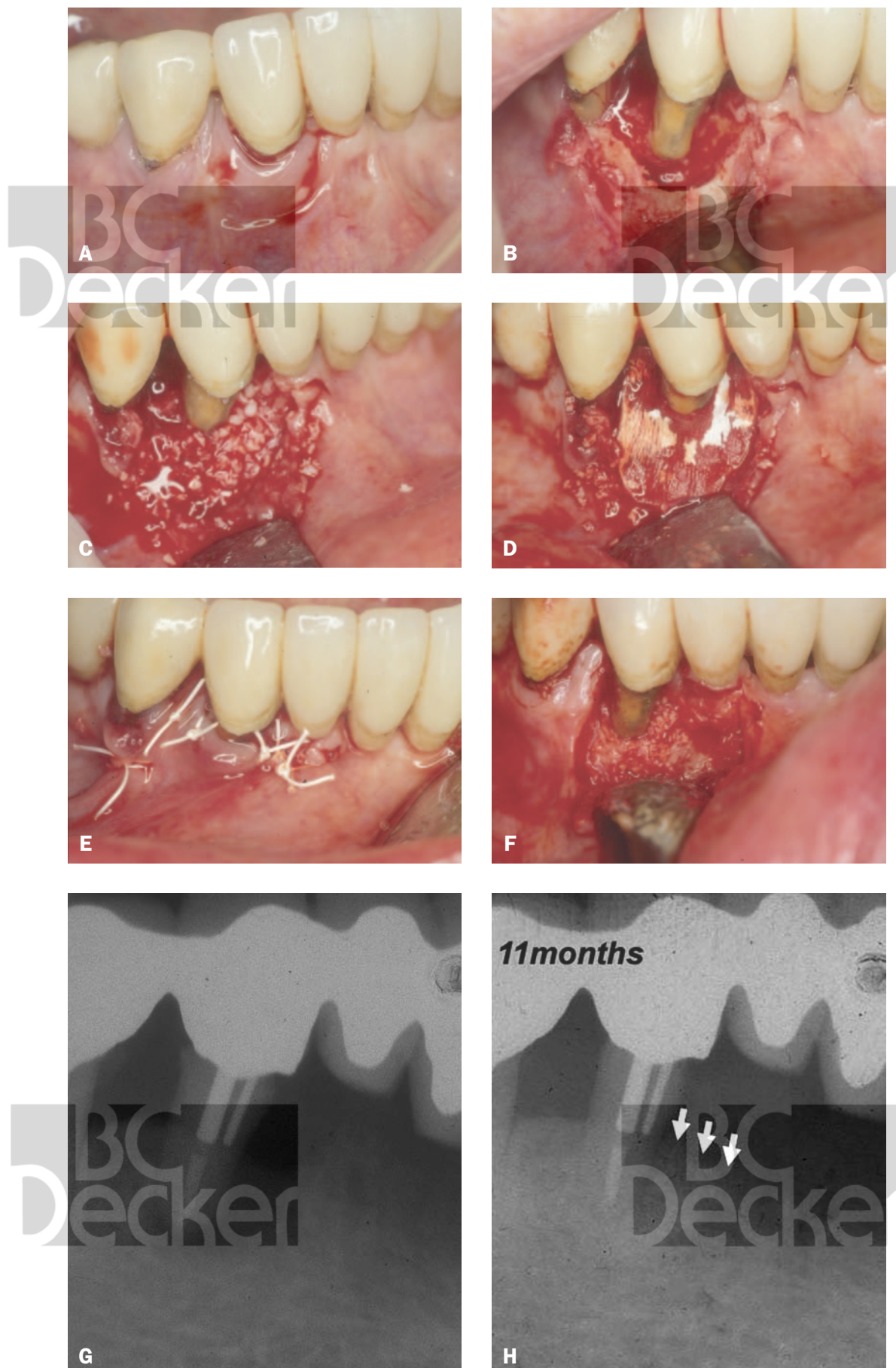


FIGURE 10-31. Guided tissue regeneration, Bio-Oss/BioGuide. *A*, Before treatment. *B*, Defect granulation. *C*, Bio-Oss positioned. *D*, BioGuide positioned. *E*, Flap replaced and sutured with Gore-Tex sutures. *F*, Reentry 11 months later. Complete defect resolution. *G* and *H*, Pre- and post-treatment radiographs showing complete regeneration.



FIGURE 10-32. Guided tissue regeneration in mandibular furcations with resorbable membranes and xenograft. *A*, Before; deep grade II furcation. *B* and *B'*, Xenograft (Bio-Oss) placed. *C*, Resorbable membrane (RCM[®][Ace Surgical Supply, Brockton, Massachusetts]) positioned. *C'*, Resorbable membrane (Resolute[®], Adapt[®], WL Gore Inc, Flagstaff, Arizona) positioned and sutured. *D* and *D'*, Reentry 12 months later showing complete regeneration.



FIGURE 10-33. Guided tissue regeneration of a grade II maxillary furcation with a resorbable membrane. *A*, Before. *B*, Grade II maxillary furcation exposed. *C*, Xenograft placed (Bio-Oss). *D*, Resorbable membrane (Bio-Mend®, Zimmer Dental, Carlsbad, California) positioned. *E*, Flap positioned and sutured. *F*, Reentry 12 months later showing 100% regeneration.

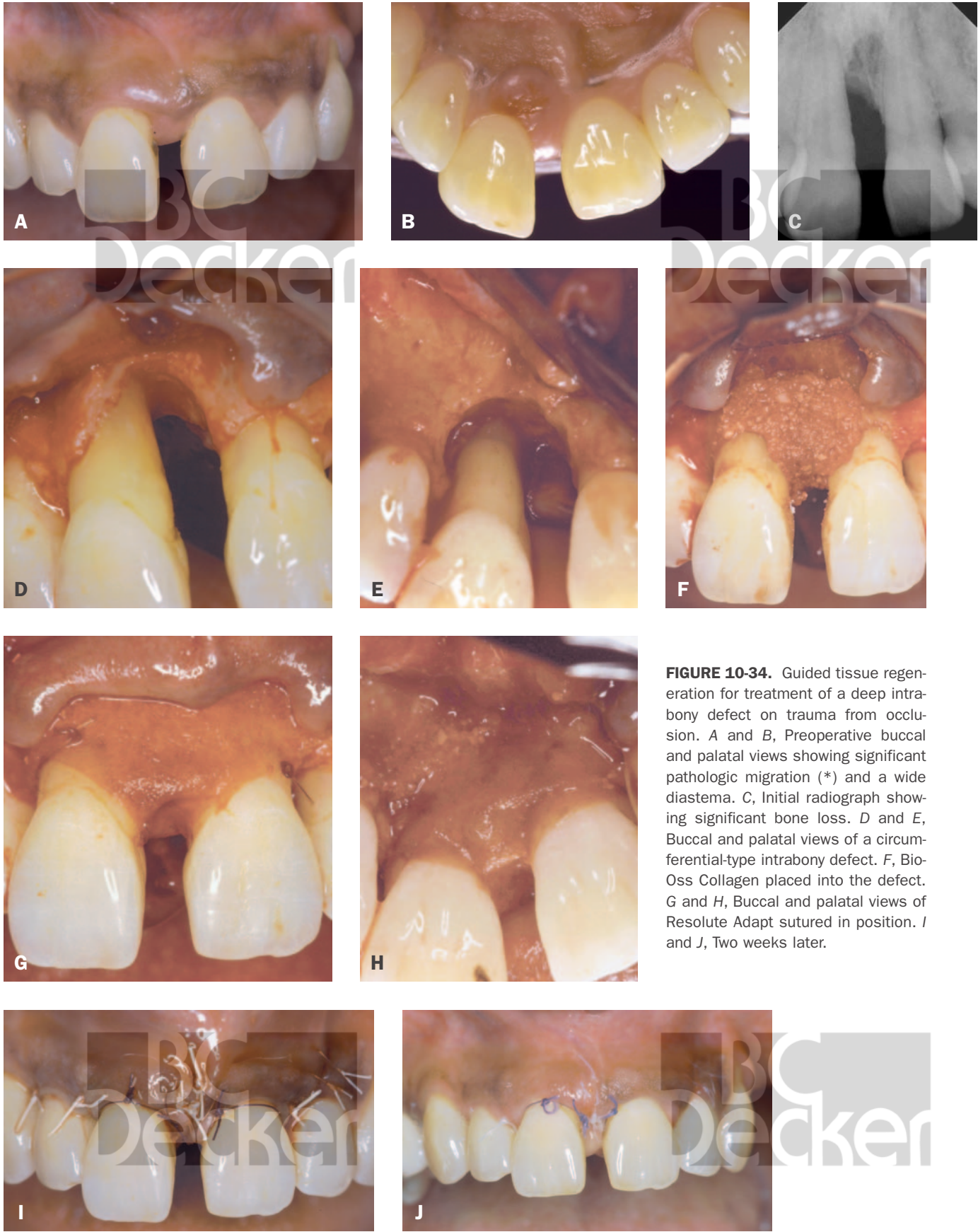


FIGURE 10-34. Guided tissue regeneration for treatment of a deep intrabony defect on trauma from occlusion. A and B, Preoperative buccal and palatal views showing significant pathologic migration (*) and a wide diastema. C, Initial radiograph showing significant bone loss. D and E, Buccal and palatal views of a circumferential-type intrabony defect. F, Bio-Oss Collagen placed into the defect. G and H, Buccal and palatal views of Resolute Adapt sutured in position. I and J, Two weeks later.



FIGURE 10-34. (continued) *K* and *K'*, One month later; clinical and radiographic views. *L* and *L'*, Two months later; clinical and radiographic views. *M* and *M'*, Three months later; clinical and radiographic views. *N* and *N'*, Four to five months later. Tooth has assumed a normal position within proximal bone still healing. Note that occlusal adjustments were performed on a monthly basis to provide adequate room for tooth retraction and reduction in trauma from occlusion.

Table 10-3 Alloplastic Bone Grafting Materials and Xenografts

Product Name	Manufacturing Material	Mode of Breakdown	Particle Size Available	Reconstruction Needed	Resorbable	Dispensing Method	Company Name
Bio-Oss*	Natural purified bone mineral	Osteoclasts	250–1,000 μm and 1.0–2.0 mm	Yes, with saline, blood, or osseous coagulum	Yes	Single-use vial	Osteohealth Co.
\pm NuOss	Natural purified bone material	Osteoclasts	.25 – 1 mm	Yes, with saline, blood, or osseous coagulum	Yes	Single-use vial	Ace Surgical Supply
Bioplant HTR Synthetic Bone Alloplast	Calcified microporous copolymer	Not applicable	500 and 700 μm	No	No	Preloaded syringes, sterile syringes, and sterile dappen dishes	Bioplant Inc.
PerioGlass	Bioactive glass	Leaching dissolution	90–710 μm	No	Small particles resorbable; large decrease in size with time	Single-use vial	Block Drug Company, Inc.
OsteoGraf/LD	C, HA, N	Solution-mediated resorption	250–420 μm	Yes, with sterile saline or sterile water	Yes	Multiuse vial	CeraMed Dental, LLC
OsteoGraf/N-300	C, HA, S	Cell-mediated resorption	250–420 μm	Yes, with sterile saline or sterile water	Yes	Multiuse vial	CeraMed Dental, LLC
Pepgin P-15	Bovine bone	Cell-mediated resorption	250–420 μm	Yes, with sterile saline or sterile water	No	Multiuse vial	CeraMed Dental, LLC
OsteoGraf/D	C, HA, S	Nonresorbable	250–420 μm 420–1,000 μm	Yes, with sterile saline or sterile water	Yes	Multiuse vial	CeraMed Dental, LLC
Capset Calcium Sulfate Bone Graft Barrier Kit	C, calcium sulfate, α -hemihydrate	Hydrolysis	40 μm	Yes, with enclosed premeasured accelerating solution only	Yes, 4–6 wk	Single-use vial	Lifecore Biomedical
Orthomatrix Hydroxylapatite Bone	C, HA, S	Not applicable	HA 1000, 420–840 μm	Yes, with blood, saline, or antibiotic solution	No	Reloaded syringes	Lifecore Biomedical
Hapset Hydroxylapatite Bone Graft Plaster	C, HA (calcium sulfate added)	Hydrolysis	250 μm	Yes, with enclosed premeasured accelerating solution only	Semiresorbable at 4–6 wk	Single-use vial	Lifecore Biomedical
Biogran	Bioactive glass	Osteoclasts	300–355 μm	No	Resorbs in 6 mo if site is loaded	Single-use vial, preloaded syringes	Orthovita
Calcitite 20-40	Lifecore Biomedical	Not applicable	420–840 μm	No	No	Single- or multiuse vial or preloaded syringes	Sulzer Calcitek
Calcitite 40-60	Lifecore Biomedical	Not applicable	250–420 μm	No	No	Single- or multiuse vial or preloaded syringes	Sulzer Calcitek\

C = ceramic; HA = hydroxyapatite; HTR = hard tissue replacement; N = natural; S = synthetic.
 *Only material to histologically show true regeneration (Nevins and colleagues, 2003).
 \pm Almost identical to Bio-Oss, but lacks histologic data to show regenerative potential.

Guided Tissue Regeneration

If the ultimate goal of periodontal therapy is regeneration of the lost supporting tissues (bone, cementum, and periodontal ligament [PDL]), the apical proliferation and migration of the epithelium must be prevented (Stahl, 1977, 1986). For it is the rapid apical proliferation that results in healing by a long junctional epithelium (LJE), which precludes regeneration and results in repair (Melcher, 1976; Aukhil and colleagues, 1988). The concept of guided tissue regeneration (GTR) is one that attempts to exclude or prevent this apical proliferation of epithelium in favor of other cells that will increase the likelihood of regeneration—bone and PDL (McHugh, 1988).

The true nature of the attachment achieved can be determined only histologically. Even with regeneration of bone, one cannot be sure that healing is not by an LJE. Caton (1980) analyzed the results from four different types of surgical procedures—scaling and root planing, modified Widman flaps with either débridement alone or in conjunction with autogenous or synthetic bone grafts—and found that all healed by an LJE. This was also confirmed by others. The only exception to this is when various bone grafting materials are used (Bowers and colleagues, 1982, 1985, 1989b).

Ellegaard and colleagues (1974) used free gingival grafts to cover osseous defects that had received implants to retard the rapid apical migration of the epithelium. They found a significant gain in new attachment with and without bone grafts. Histologically (Ellegard, 1983), the apical proliferation of the epithelium was shown to be delayed 10 to 12 days, resulting in less pocketing and greater connective tissue attachment.

Melcher (1976) postulated that four different connective tissues compete for the root surface during healing: (1) the lamina propria of the gingiva with the gingival epithelium, (2) the PDL, (3) the cementum, and (4) the alveolar bone. Which cell phenotype succeeds in repopulating the root surface determines the nature and quality of the attachment and regeneration (Figure 11-1).

The biologic basis for GTR was borne out of this type-specific cell repopulation theory. Melcher (1962, 1976) and Aukhil and colleagues (1988) showed that each cell type results in a specific type of repair or regeneration of gingival epithelium: LJE, bone ankylosis, gingival connective tissue–root resorption, and PDL regenera-

tion (bone, cementum, and PDL) (see Figure 11-1). Aukhil and colleagues (1988) demonstrated that although the PDL and bone compartments are individual, they do blend together to help in regeneration and new attachment.

Animal Studies

A number of studies were undertaken to determine the nature and quality of the attachment when the root surface was repopulated by different selected cell types. Karring and colleagues (1980) found that roots submerged in the bone resulted in ankylosis. Nyman and colleagues (1980) submerged roots between the gingival connective tissue and the bone. They found resorption adjacent to the gingival connective tissue and ankylosis next to the bone. Neither tissue appeared to be capable of producing a true connective tissue attachment. Nyman and colleagues (1982) used a Millipore filter over a window created in the bone and found that only when cells from the PDL were allowed to repopulate the wound was total regeneration achieved. Gottlow and colleagues (1984) used both a Millipore filter and a Gore-Tex membrane (W.L. Gore, Inc. Flagstaff, Arizona) over submerged roots in monkeys to demonstrate repopulation of the wound by cells of the PDL, resulting in a considerably greater increase in new attachment of the test teeth. The need for selective repopulation from the PDL was confirmed by Karring and colleagues (1986) using a combination of tight and loose elastics about the roots to prevent or permit cell repopulation from the PDL. They found that regeneration happened only when cells from the PDL were allowed to populate the root.

Human Studies

The successful use of barriers in the animal model led to their use in human clinical trials. Nyman and colleagues (1982) tested the hypothesis of GTR on a single mandibular incisor using a Millipore filter (Figure 11-2). He was able histologically to show 5 mm of new attachment above the alveolar crest 3 months later. Gottlow and colleagues (1986) studied 12 teeth (5 histologically) in 10 patients in whom mucoperiosteal flaps were used with underlying Teflon membranes. The results indicated “that a regenerative surgical therapy based on the principles of guid-

ed tissue regeneration predictably results in connective tissue attachments” in both intrabony defects and furcations and that “variations in results may be due to morphologic differences in defects allowing for greater or lesser amount of periodontal ligament cells is at least as high as that of bone cells.” Caffesse and colleagues (1991), on the basis of their previous research, postulated that “repopulation of the treated root surfaces by cells originating from the periodontal ligament is needed to prevent root resorption and dentoalveolar ankylosis.” He and others (Boyle and colleagues, 1983; Gottlow and colleagues, 1984; Lindhe and colleagues, 1984; Houston and colleagues, 1985) also found that citric acid (CA) and tetracycline hydrochloride (TTC) did not enhance the effectiveness of the membrane.

Note: One of the earliest attempts of GTR using a Millipore filter was in 1971 (Dines and Cohen; Figure 11-3).

Intrabony Defects

A number of studies have shown that in intrabony defects, significant new connective tissue attachment gains can occur without similar increases in alveolar bone and that the amount of new attachment versus the amount of bone regeneration varies with the specific site when the GTR technique is used (Boyle and colleagues, 1983; Gottlow and colleagues, 1984; Lindhe and colleagues, 1984; Houston and colleagues, 1985). This connective tissue and bone variance have been interpreted to mean that bony tissue regrowth and PDL regeneration are unrelated. Gottlow and colleagues (1986) noted that bony regeneration may be restricted to angular as opposed to horizontal defects because of a combination of the greater surface area, which provided more osteogenic cells, and the walls of the defect, which provide a potential space for cells to migrate into.

These findings are in opposition to those of Becker and colleagues (1988) and Handelsman and colleagues (1991), who found that bone fill in intrabony defects correlated closely to attachment gains. Cortellini and colleagues (1993a, 1993b) and Tonetti and colleagues (1993) recently found a mean bone regeneration of 4.3 ± 2.5 mm 1 year following treatment of 40 deep vertical defects. Overall, they achieved 100% fill in 32.5% of the cases, $\geq 50\%$ fill in 57.5% of the

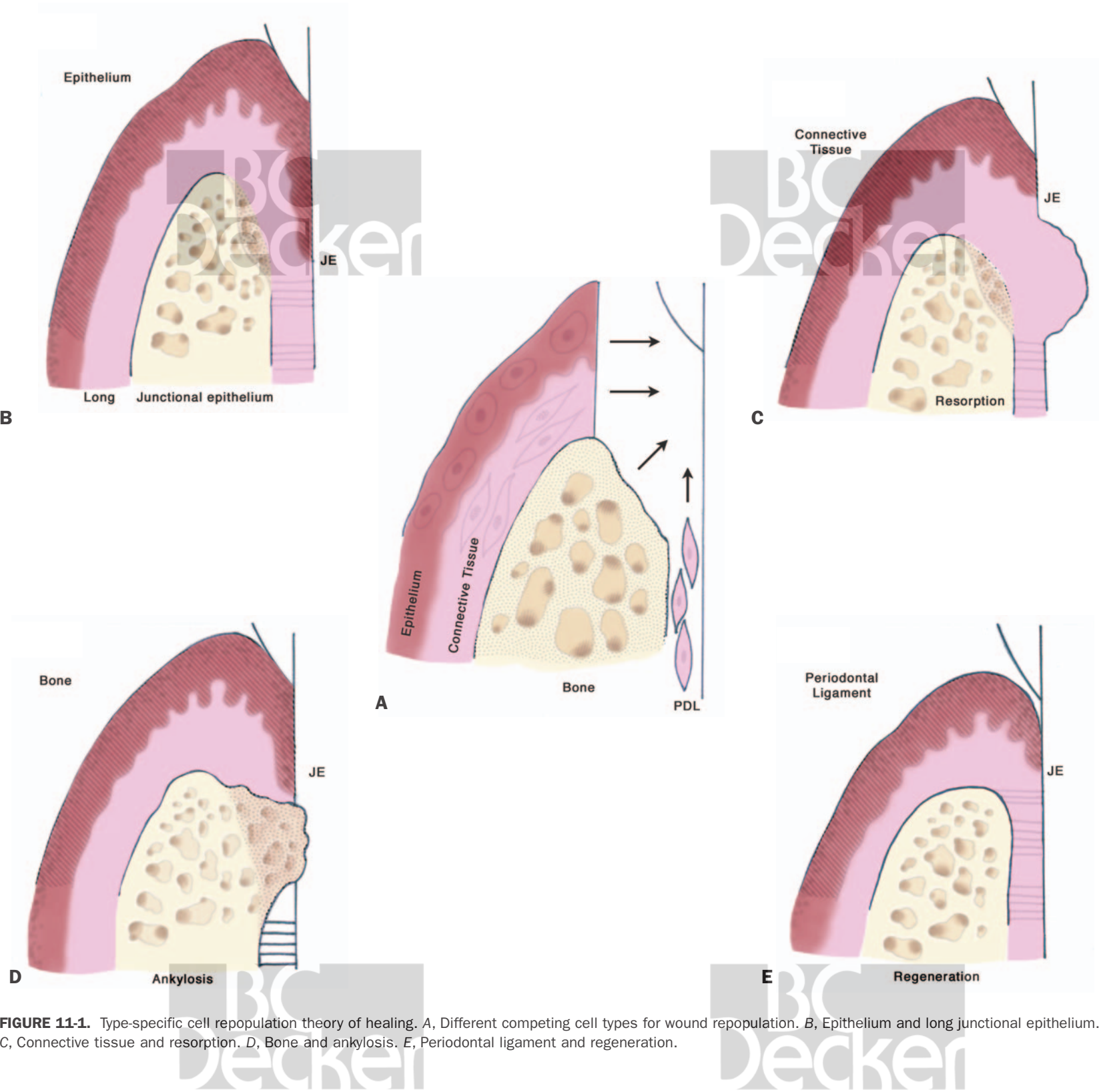


FIGURE 11-1. Type-specific cell repopulation theory of healing. *A*, Different competing cell types for wound repopulation. *B*, Epithelium and long junctional epithelium. *C*, Connective tissue and resorption. *D*, Bone and ankylosis. *E*, Periodontal ligament and regeneration.

cases, and < 50% only 10% of the time. They concluded that the combination of GTR and a strict plaque control program resulted in clinically significant and highly predictable bone regeneration. Lindle and colleagues (2003) and Laurell and colleagues (1998), in comprehensive reviews of the literature (78 trials; 1,795 defects), found a number of factors to be significant when com-

paring GTR with conventional open flap débridement (OFD) in intrabony defects:

1. Bioabsorbable membranes were equal to nonabsorbable membranes.
2. GTR had significantly greater mean clinical attachment level gain (CAL-G) and bone fill than OFD.

3. Defect anatomy (one, two, or three walls) was not a factor.
4. Narrow defects (radiographic angle of $\leq 27^\circ$) gained significantly more CAL-G than wide defects ($\geq 37^\circ$).
5. The minimum treatable defect depth should be ≥ 4 mm.

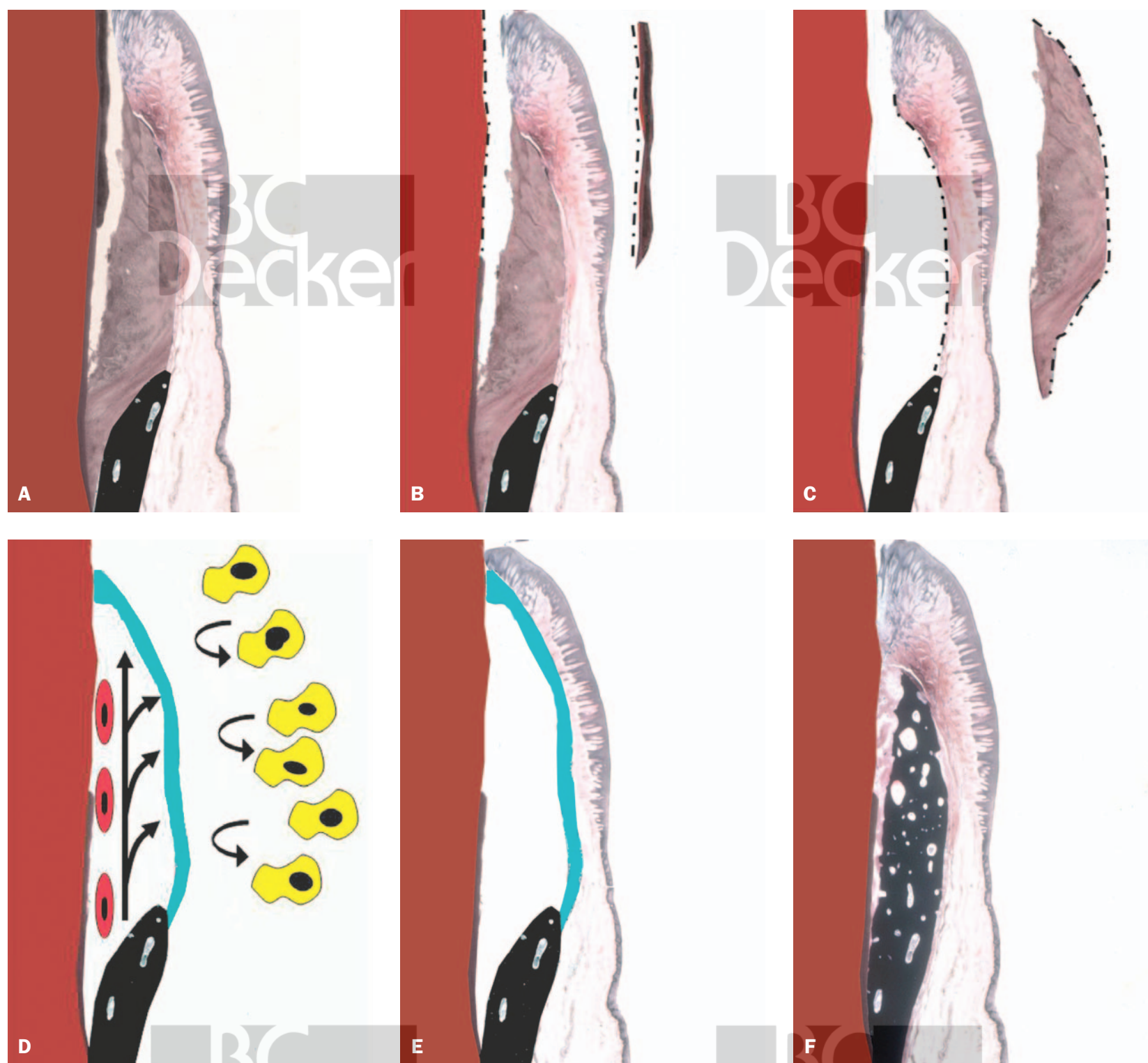


FIGURE 11-2. Guided tissue regeneration. A, Periodontal disease: calculus, pocket formation, inflammation, and bone loss. B, Calculus removal and root planing. C, Removal of the inflamed undersurface of the flap. D, Membrane positioned to prevent epithelial cell migration and promote cellular growth from the periodontal ligament and bone. E, Flap positioned over the membrane. F, Regeneration.

6. Excessive mobility may impair clinical results.
7. Endodontics does not affect the outcome of GTR.
8. The greatest percentage of defect fill occurs in defects of 4 to 5 mm.
9. Deep narrow defects treated by GTR offer the most predictable outcomes.

10. Residual pocket depth of 2.3 to 3.5 mm after 1 year.
11. Bone grafts do not enhance outcomes when GTR is used.

Cortellini and Tonetti (2005), in their study of intrabony defects with GTR, combined clinical experience with evidence-based treatment

planning. Using microsurgical techniques, they found that if primary flap closure was achieved, plaque control and compliance were maintained, and their protocol for differing defect anatomies was followed (Figure 11-4), all GTR procedures achieved an average CAL-G of 6 ± 1 mm or $92.7 \pm 12\%$.

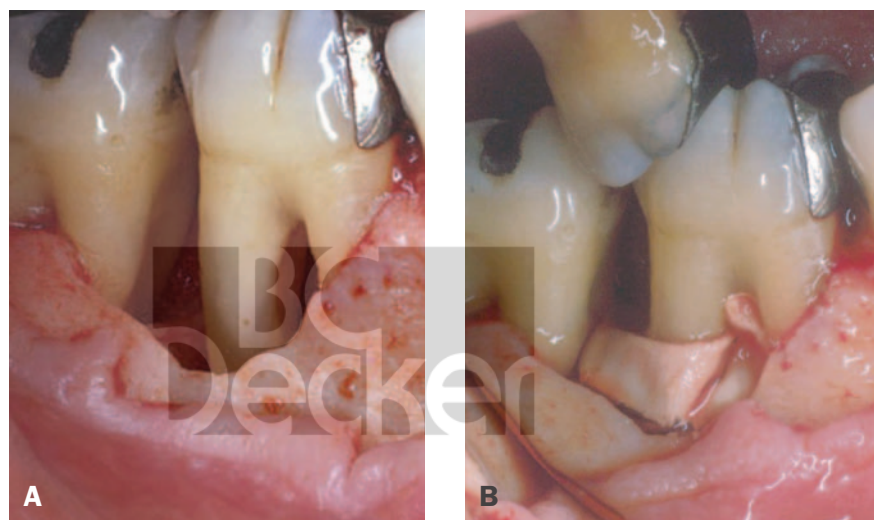


FIGURE 11-3. Early documented attempt of GTR using a Millipore® (Millipore Co., New Bedford, Massachusetts) filter (1971). A, Intrabony defect. B, Millipore filter positioned. Note incorrect positioning in failure of procedure.

Furcations

Becker and colleagues (1988) studied grade II, grade III, and intrabony defects in 27 patients and found a gain in new attachment of 2.3 and 1.5 mm for grade II and III furcations, respectively, with a 3.7 mm gain for vertical defects ($< .01$). It is important to note that the authors coined the term “open probing attachment” to describe a tissue that was not bone but was firm, was resistant to probing forces, and had the consistency of a rubber dam. No radiographic changes were evident.

In a series of studies, Pontoriero (1987, 1988, 1989, 1992) studied grade II and III defects in humans using expanded polytetrafluoroethylene (e-PTFE) (Gore-Tex periodontal material). Using a calibrated probe with a standardized pressure, he found that 90% of grade II and 25 to 35% of grade III furcations were nonprobable as opposed to the controls, for which only 20% of grade II and 0% of grade III furcations were nonprobable. Partial fill was achieved in 50 to 60% of the grade III test sites. Finally, it was noted that in grade III furcations with an entrance height of over 3 mm, he was unable to complete defect closure. Complete closure occurred only when the entrance height was less than 3 mm.

Metzer and colleagues (1991) found that GTR had limited application as a therapeutic modality for the mesial and distal grade II furcations of maxillary molars. In a reentry study, Lekovic and colleagues (1989) found no difference in the bone level between test subjects and controls, although there were significant improvements in the pocket depth of 4.09 mm at the test sites.

Selvig (1990) postulated that successful membrane results were achieved owing to the fact that the membrane potentiates or contributes to clot stability and protection by protecting the clot from the disruptive movements of the overlying flap.

Gottlow and Karring (1992) studied the maintainability of new attachment gains by GTR for 5 years and concluded that “the results demonstrated that the attachment gain obtained as a result of the GTR treatment could be maintained over periods of up to 5 years.”

Lindhe (2003), in a review of 21 clinical trials (423 mandibular grade II furcations), found the following:

1. There was no significant difference between bioabsorbable and nonabsorbable membranes.
2. GTR significantly improved the horizontal clinical attachment level (CAL-H) clinical result over open flap surgery: 2.5 versus 1.3 mm.
3. Complete closure was variable (0–67%).
4. GTR significantly improved vertical attachment and a reduction in pocket depth.
5. CAL-H in maxillary furcation was only 1.6 mm, and the results were variable.
6. The first and second mandibular molars were equal.

Bowers and colleagues (2003), in a multicenter study on e-PTFE and demineralized freeze-dried bone allograft (DFDBA) in grade II mandibular furcations, found complete closure in 84 and 68% of the remaining defects went from Class II to Class I.

Combination Grafts

In an attempt to overcome this bone–connective tissue variance, a number of different osteogenic (inductive, conductive, neutral) materials have been employed under the barrier. Schallhorn and McClaine (1988) used an e-PTFE membrane (Gore-Tex periodontal material) with DFDBAs or tricalcium phosphate and CA versus e-PTFE membrane alone. They found that although attachment gains were similar between the two groups, 72% (33 of 46) of the furcations having the combined treatment had complete furcation bone fill as opposed to 31% (5 of 16) for the membrane alone. In the vertical furcation defects, the respective attachment gains were 5.3 versus 4.5 mm for the membrane and graft and membrane alone, and gains of 4.2 (membrane and graft) to 3.1 mm (membrane only) were seen for horizontal furcal probing. CA appeared to increase the favorable results in both vertical defects and furcations.

Kerstein and colleagues (1992) found that the use of CA did not enhance the positive effects. The World Workshops in Periodontics (WWP) (1996, 2003) and the AHP (2005) agreed that although there is statistically significant histologic evidence demonstrating regeneration with CA root surface conditioning, the results clinically are not significant.

McClaine and Shallhorn (1993) found membrane-only site regression after 53 to 70 months such that the membrane and graft group now became statistically significant for clinical probing attachment levels ($p = .005$) and for horizontal probing depth ($p = .003$). In grade II furcation initially showing complete furcation fills with the membrane alone, two of five (40%) remained completely filled in the long term. There was no such change in the membrane and graft group. Overall, they found 31% regression for the sites treated by the membrane alone. This was opposed to Gottlow and Karring (1992), who found no significant changes after 4 to 5 years.

In a reentry study, Anderegg and colleagues (1991) compared DFDBA with the e-PTFE (Gore-Tex periodontal material) membrane with the membrane alone. They found that although both techniques showed significant improvement in bone and probing attachment levels, the combination of graft plus membrane resulted in a significant ($p = .05$) increase in both vertical and horizontal bone fill compared with the membrane alone. This was in spite of the fact that the probing attachment gains were not statistically different between the two groups. Lekovic (1990) used porous hydroxyapatite in combination with an e-PTFE membrane and found that those cases treated by the combination technique showed a

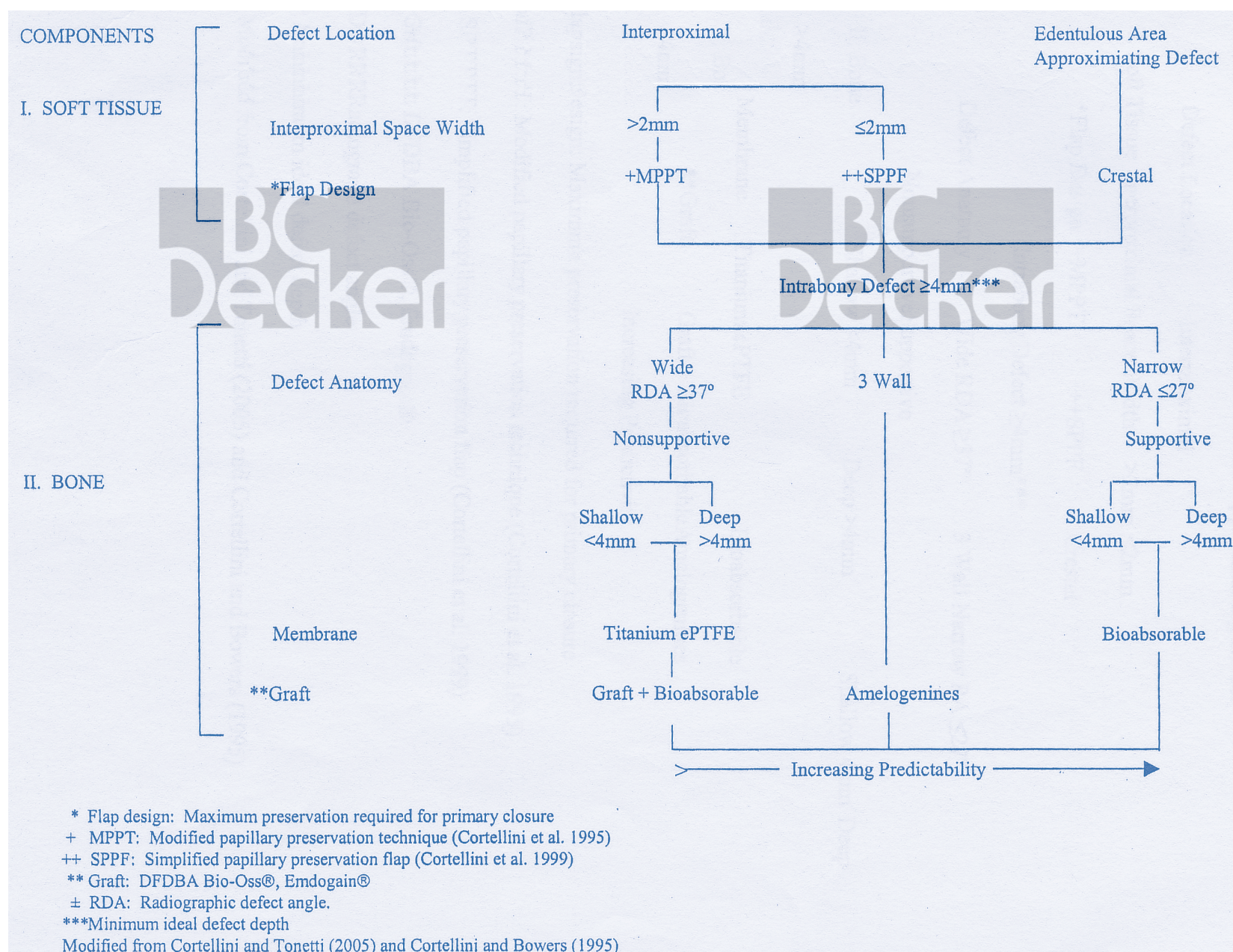


FIGURE 11-4. Guided tissue regeneration evidence-based treatment decision tree.

“gain in clinical attachment and horizontal and vertical bone fill while the lesions with the membrane only gained probing attachment with less bone fill.”

Stahl and Froum (1991) histologically showed new attachment and bone regeneration when membranes were combined with DFDBA in humans. Camelo and colleagues (2000) showed complete furcation closure of 89% when using autogenous bone with e-PTFE membranes.

The WWP (Garrett, 1996; Murphy and Gunsolly 2003; Reynolds and colleagues, 2003) and the American Academy of Periodontology (Wang 2005) paper on periodontal regeneration in intrabony defects and furcations found the following:

1. GTR provided additional benefits over OFD in clinical attachment level, reduced probing in intrabony defects, and furcations.
2. Bone replacement grafts enhance GTR treatment outcomes in furcations.
3. Bone replacement grafts do not enhance treatment outcomes for intrabony defects treated with GTR.
4. Bioabsorbable and nonabsorbable membranes provide similar outcomes in intrabony defects and horizontal probing attachment level furcations.
5. Only e-PTFE membranes significantly enhanced the vertical probing attachment level in furcations.
6. Coronally positioned flaps with CA are associated with better clinical outcomes in furcation defects.
7. Morbidity is similar for bioabsorbable membranes and OFD.
8. The following procedures or materials were capable of achieving human histologic regeneration:
 - a. Autogenous bone
 - b. Demineralized freeze-dried bone allograft
 - c. Xenograft (Bio-Oss)
 - d. Citric acid
 - e. Guided tissue regeneration
1. Nonabsorbable e-PTFE

2. Bioabsorbable
 - a. Collagen
 - b. Polyglactic acid (PLA)
 - c. Polyglycolic acid (PGA)
 - d. A combination of PLA and PGA
9. Clinically, GTR procedures for furcations should be limited to mandibular and maxillary buccal grade II furcation defects.
10. Only limited results are obtainable for mandibular (grade III) and maxillary medial and distal grade I or III furcation defects.

Note: Postsurgically, Cortellini and colleagues (1994) found that attachment level loss was 50 times greater in patients without proper maintenance, 168 times greater at sites with plaque, and 22 times greater at sites with bleeding on probing. Therefore, the need for a long-term maintenance program cannot be stressed enough.

Conclusions

The Proceedings of the World Workshop in Clinical Periodontics (1989) defined GTR as a procedure that attempts regeneration through differential tissue responses. *The WWP (1996) concluded that GTR provides significant positive clinical outcomes in Class II furcations and intrabony defects, that periodontal regeneration in humans is possible, and that regenerative techniques can lead to significant amounts of regeneration.* Finally, the WWP differentiated new attachment from regeneration in that the former consists of a new epithelial adhesion or connective tissue attachment with or without cementum on a root surface that was previously deprived of its original attachment apparatus, whereas the latter is restitution of bone, cementum, and the PDL on a previously diseased root surface.

Membranes

Nonresorbable Membranes. *Gore-Tex Barrier.* At the present time, e-PTFE or Gore-Tex is considered the “gold standard” (Murphy and Gunsolly, 2003) by which all membranes are compared. It is a biocompatible porous material possessing two unique microstructures. One is the open microstructure of its collar, which is designed to retard or inhibit the apical proliferation of epithelium through contact inhibition. The other is the occlusive membrane, which acts as a barrier to the gingival connective tissues and the underlying root surface while still allowing them to integrate with it, and this further retards epithelial downgrowth. The membrane comes in various sizes (Figure 11-5).

Procedure Guidelines. **PATIENT SELECTION.** In the medically compromised patient (eg, heart murmur, mitral valve prolapse, rheumatic heart disease, uncontrolled diabetes, heart or other prosthetic devices), the addition of a prosthetic

device such as Gore-Tex periodontal material may increase the risk of complications.

INDICATIONS.

1. Patients with good oral hygiene
2. Adequate keratinized gingiva; the material should be covered with a thick, heavy keratinized gingiva

DEFECT SELECTION. Defect selection may have the greatest impact on the predictability of the regenerative result.

MOST PREDICTABILITY.

1. For grade II furcations on teeth with high interproximal bone, a large vertical component, space-making morphology, long root trunks, and good evidence of loss in a furcation. Furcations opening at the cementoenamel junction make coverage and closure difficult.
2. Two- to three-wall intrabony vertical defects ≥ 4 to 5 mm

MODERATE PREDICTABILITY.

1. Maxillary mesial or distal Class II furcations
2. Two-wall defects.

LOW PREDICTABILITY.

1. Class III furcation with high interproximal bone, long root trunks, a large vertical component, and space-making morphology
2. One-wall defect

LEAST PREDICTABILITY.

1. Class III furcations with horizontal bone loss
2. Horizontal bone loss

Bowers and colleagues (2003), in a multicenter study of the factors influencing the outcome of regeneration therapy of Class II mandibular furcations, found the following factors to be of significance:

1. Success was directly proportional to the interproximal bone height (IBH) relative to the roof of the furcation (ROFF)
 - a. 94% when IBH \geq ROFF
 - b. 70% when IBH < ROFF
2. Success was inversely proportional to
 - a. Horizontal probing depth
 - ≥ 5 mm, 53%
 - ≤ 4 mm, 84%
 - b. Root divergence
 - ≥ 4 mm, 61%
 - ≤ 3 mm, 93%
 - c. Distance from ROF to the base of the defect
 - d. Distance from ROF to the crest of bone
 - e. Root trunk length
 - Short, ≤ 4 mm, 71%
 - Long, 5 to 6 mm, 100%
 - f. Intraradicular root concavities
3. Smokers had a significantly higher furcations that responded poorly

4. Nonsignificant factors:
 - a. Age
 - b. Gender
5. Root trunk concavities (Lu, 2002; Villaco and colleagues, 2004) result in significantly less horizontal depth resolution.

CONTRAINDICATIONS

1. In cases in which flap vascularity will be compromised
2. Very severe defects—minimal remaining periodontium
3. Horizontal defects
4. In case of flap perforation

TREATMENT OPTIONS

1. Bone replacement grafts
2. Adjunctive therapy
3. Guided tissue regeneration
4. Biochemical root preparation
5. Combination therapy (two or more)
 - a. Bone grafts: autogenous, DFDBA, Bio-Oss
 - b. GTR: resorbable, nonresorbable
 - c. Adjunctive therapy
1. Biochemical treatment: CA, TTC, ethylenediaminetetraacetic acid (EDTA)
2. Coronally positioned flap
3. Amelogenins (enamel matrix derivative [EMD])

SURGICAL PROCEDURE. It is important to note that the surgical principles and procedures

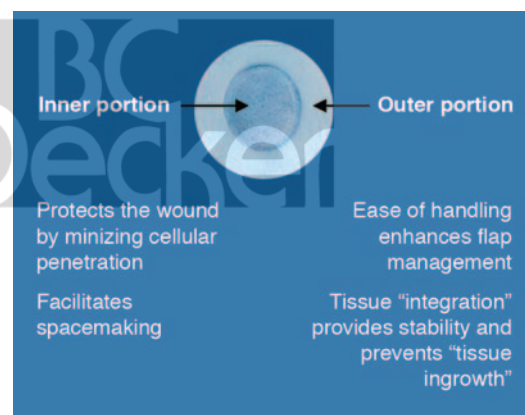


FIGURE 11-5. Different sizes of expanded polytetrafluoroethylene (Gore-Tex).

that apply to nonresorbable membranes also apply to resorbable barriers. The main differences will be in postoperative considerations and a lack of a need for a secondary removal surgery in most cases.

PRIMARY INCISIONS.

1. Intramuscular incisions are made in preparation for a full mucoperiosteal flap. Maximum conservation and preservation of the interdental papilla ensure total material coverage and primary intention healing (Figure 11-6A).
2. All residual pocket epithelium is removed after flap reflection. This will permit primary intention healing and integration between the e-PTFE and the flap connective tissue (Figure 11-6B).
3. Incisions should extend one to two teeth mesial and/or distal of the area being treated to permit adequate visualization.

Note: Cortellini (2005) recommended the modified or simplified papillary preservation flap technique to ensure primary closure.

4. Vertical incisions should be placed mesially where necessary.

DEFECT PREPARATION.

1. Degranulation of the defect. Without thorough defect débridement, predictable regenerative results cannot be expected.
2. Scaling and root planing for removal of all tooth deposits (Figure 11-6, C and D)
3. Use of additional high-speed rotary instrumentation for defect and/or root refinements
4. Optional use of biochemical root surface modifiers: CA, TTC, or EDTA. If used, the defect must be rinsed to ensure complete removal.
5. Decortification of bone for increased vascularity and scratching of the PDL to stimulate cell and vascular proliferation. Without a clot in the defect space, regeneration cannot occur.
6. Use of a bone augmentation material: autogenous bone, DFDBA, Bio-Oss, Emdogain, or a combination graft.

Note: Bone grafts have been found to enhance GTR outcomes in furcations but not in intrabony defects.

MEMBRANE SELECTION:

NONRESORBABLE OR RESORBABLE.

1. Maintain the sterility of the material.
2. Choose a size that offers the most ideal design for defect coverage (Figure 11-6, E and F).

3. Shape the material with scissors. Avoid leaving sharp edges.
4. Enough material should be left to permit lateral and interproximal suturing while leaving at least 3 mm apical and lateral overextension of the defect margin (see Figure 11-6, E and F).
5. In the case of e-PTFE, do not remove the open microstructure or coronal portion of the material. It should be trimmed only on the lateral aspects.
6. The material should fit smoothly, avoiding folds, overlaps, and protrusions, which may compromise the overlying gingival tissue.
7. In either periodontal or bony ridge defects, the amount of space beneath the material determines the maximum potential regeneration. Without space maintenance, regeneration is not possible.

Note: If the intrabony defect, furcation, or bony ridge does not provide adequate support, a titanium-reinforced e-PTFE membrane is recommended.

SUTURE MATERIAL.

1. Gore-Tex suture (provided with e-PTFE) is the recommended material for stabilizing the e-PTFE membrane and for flap closure for all membranes (Figure 11-6, G and H).
2. Silk or monofilament sutures may be used in areas away from the material.
3. Bioabsorbable sutures are recommended only for stabilizing resorbable membranes.

SUTURING TECHNIQUE.

1. If material approximation over the defect requires suturing (e-PTFE) or permits suturing (Resolute® Adapt®, [W.L. Gore Inc, Flagstaff, Arizona], RCM® [Ace Surgical Supply, Brockton, Massachusetts]) sling sutures Gore-Tex are used and completed without engaging the flap or tissue (Figure 11-6G).
2. The material must fit tightly against the tooth surface at all points to prevent epithelial proliferation between the tooth and the material and to help in stabilizing the wound.
3. The flap margin should ideally be 2 to 3 mm coronal to the material.
4. Tight flap apposition is desired to avoid premature flap opening and material exposure.
5. An apical horizontal periosteal releasing incision may enhance material coverage. Do not compromise blood supply.
6. Interproximal incisions approximating the material are closed first. The flap is sutured with Gore-Tex or Vicryl sutures and left for 2 weeks (Figure 11-6H).

MATERIAL REMOVED (E-PTFE)

1. Removal should be 4 to 8 weeks after placement or any time a serious complication occurs.
2. If the material cannot be removed with a gentle tug, sharp dissection is recommended. A sulcular incision is made to extend one tooth mesially and distally (Figure 11-6I).
3. Extreme care should be used to avoid damaging the underlying new granulation tissue. Sharp dissection is used to reflect the overlying tissue (Figure 11-6J).
4. A small tissue forceps is used to remove the material (Figure 11-6K).
5. Light curettage of the inner flap surface is recommended for removal of any epithelial remnants.
6. Do not instrument the new regenerated tissue.
7. The flap is reapproximated over the new tissue and sutured with Gore-Tex or Vicryl sutures (Figure 11-6L).

POSTOPERATIVE CONSIDERATIONS.

1. Chlorhexidine mouthwash should be used for 10 days. If the material becomes exposed, Peridex should be used until removal.
2. TTC 250 mg daily or doxycycline 100 mg twice daily should be used for 7 to 10 days.

Note: Antibiotics are ordered at the discretion of the clinician.

3. Periodontal dressing may or may not be used depending on the clinician's discretion.
4. Gentle brushing is recommended for the first -6 weeks.
5. Flossing at the treated site is to be avoided while the material is in place.
6. The patient should be seen biweekly if there is no exposure and weekly if exposure is present.
7. Do not attempt to cover previously exposed material.
8. The material should be removed immediately should any complication develop.
9. Avoid deep mechanical instrumentation and probing of the site for 6 to 9 months.

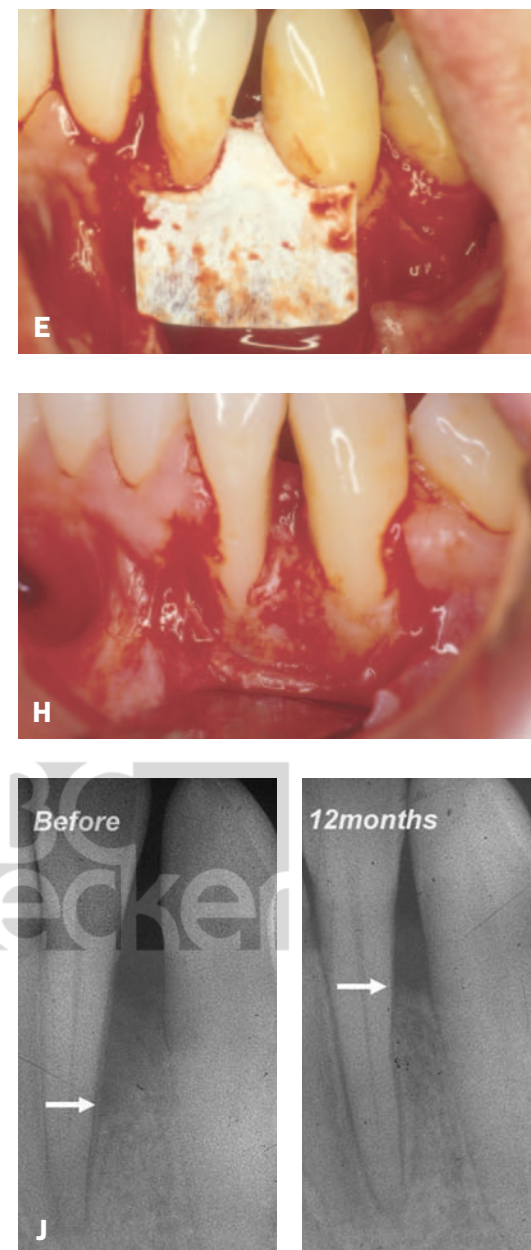
The clinical procedures for intrabony defects are depicted in Figures 11-7 to 11-9. The clinical procedures for furcations are depicted in Figures 11-10 to 11-12.



FIGURE 11-6. Guided tissue regeneration surgical procedure. *A*, Intramuscular incision. *B*, Residual pocket epithelium removal. *C* and *D*, Meticulous scaling, root planing, and tissue débridement so that the defects are completely devoid of tissue. *E*, Membrane placed over the furcation area. *F*, U-shaped membrane over the distal defect. *G*, Membranes sutured with Gore-Tex sutures: occlusal and buccal views. *H*, Suturing completed with interrupted sutures. *I* and *J*, Membrane removal. Flaps are reflected by sharp dissection for removal of ingrown tissue and epithelium from under the flap. *K*, Membranes are removed. *L*, Final suturing with interrupted sutures.



FIGURE 11-7. Treatment of an intrabony defect by guided tissue regeneration. **A**, Before. Note 12-mm pocketing with purulence. **B**, Flap reflected indicating the four zones to be treated: (1) Gross degranulation; (2) The root surface; (3) The transeptal fibers over the bone; and (4) Decortication to open the blood vessels. **C**, Defect cleared, roots scaled and root planed. **D**, DFDBA placed. **E**, Nonresorbable (Gore-Tex) membrane placed. **F**, Flap coronally positioned and sutured for primary coverage. **G**, Gore-Tex removed at 10 weeks. Note new bone formation. **H**, Reentry 12 months later. **I**, Before and after. Note about 5 mm gain in bone height. **J**, Pre- and post x-rays.



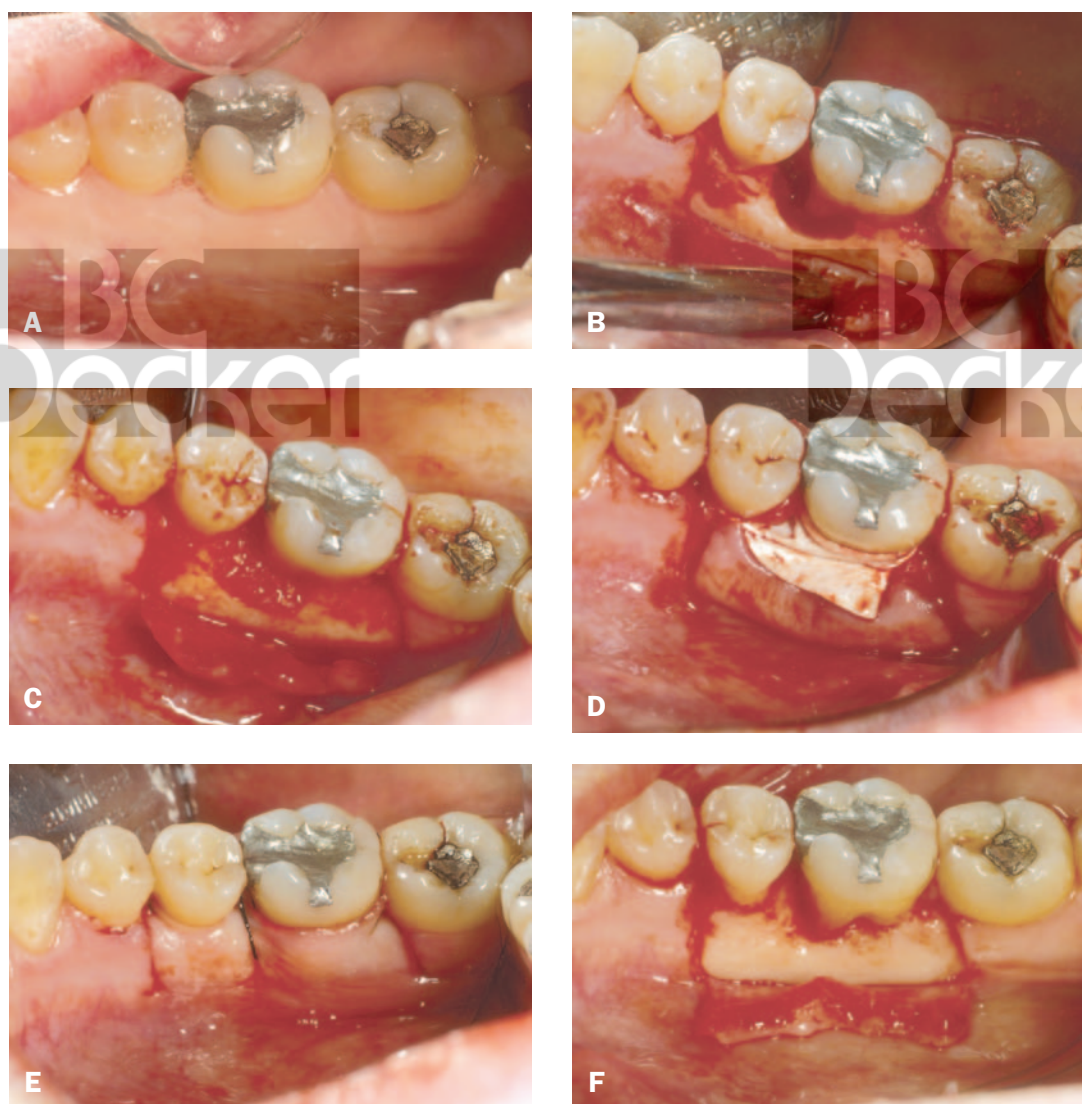
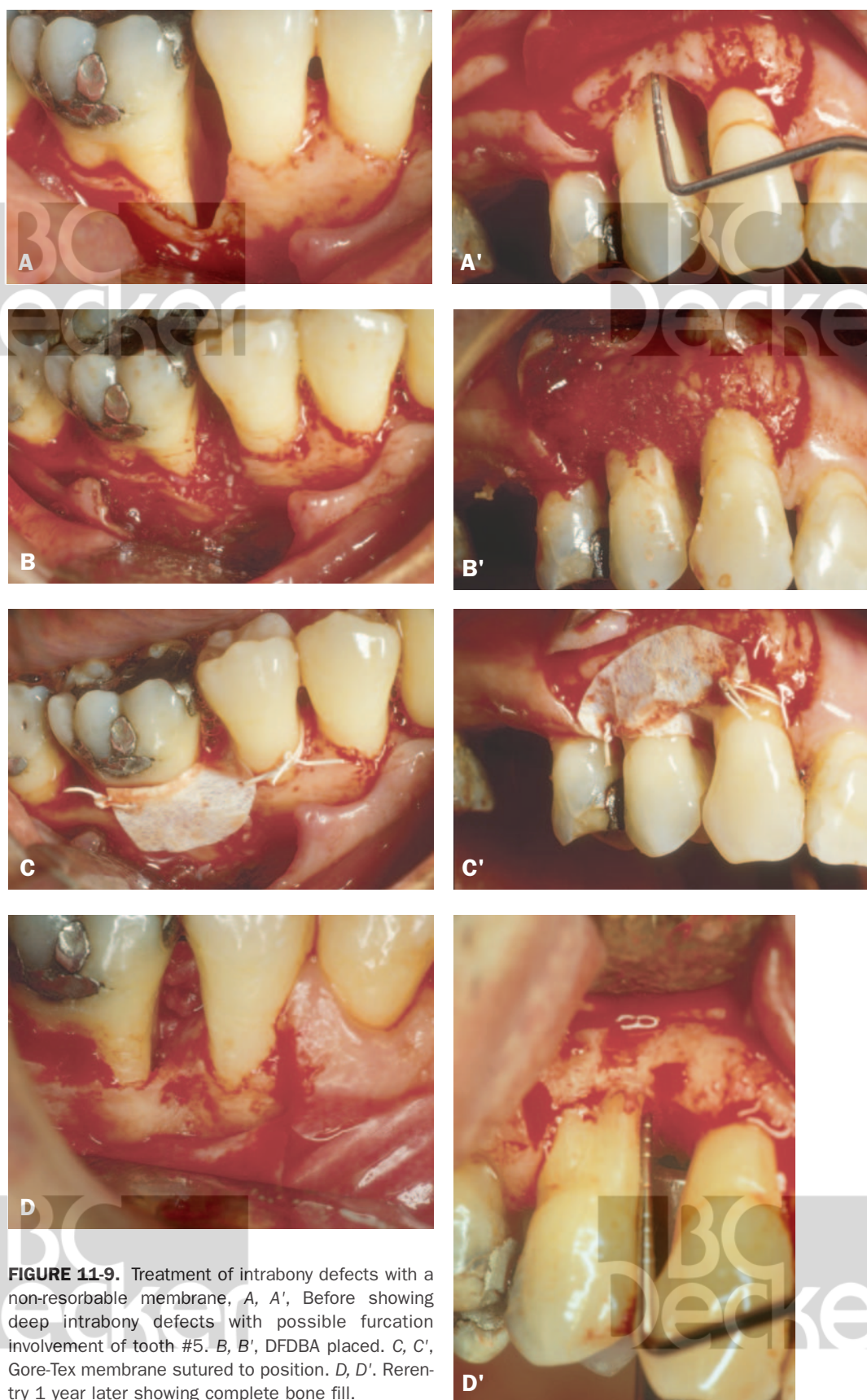


FIGURE 11-8. Guided tissue regeneration of an intrabony defect and incipient furcation. *A*, Before treatment. *B*, Two-surface three-wall defect exposed with incipient furcation. *C*, Demineralized freeze-dried bone allograft placed. *D*, Expanded polytetrafluoroethylene membrane placed. *E*, Flap repositioned. *F*, Reentry after 1 year. Note complete fill of the defect and incipient furcation.



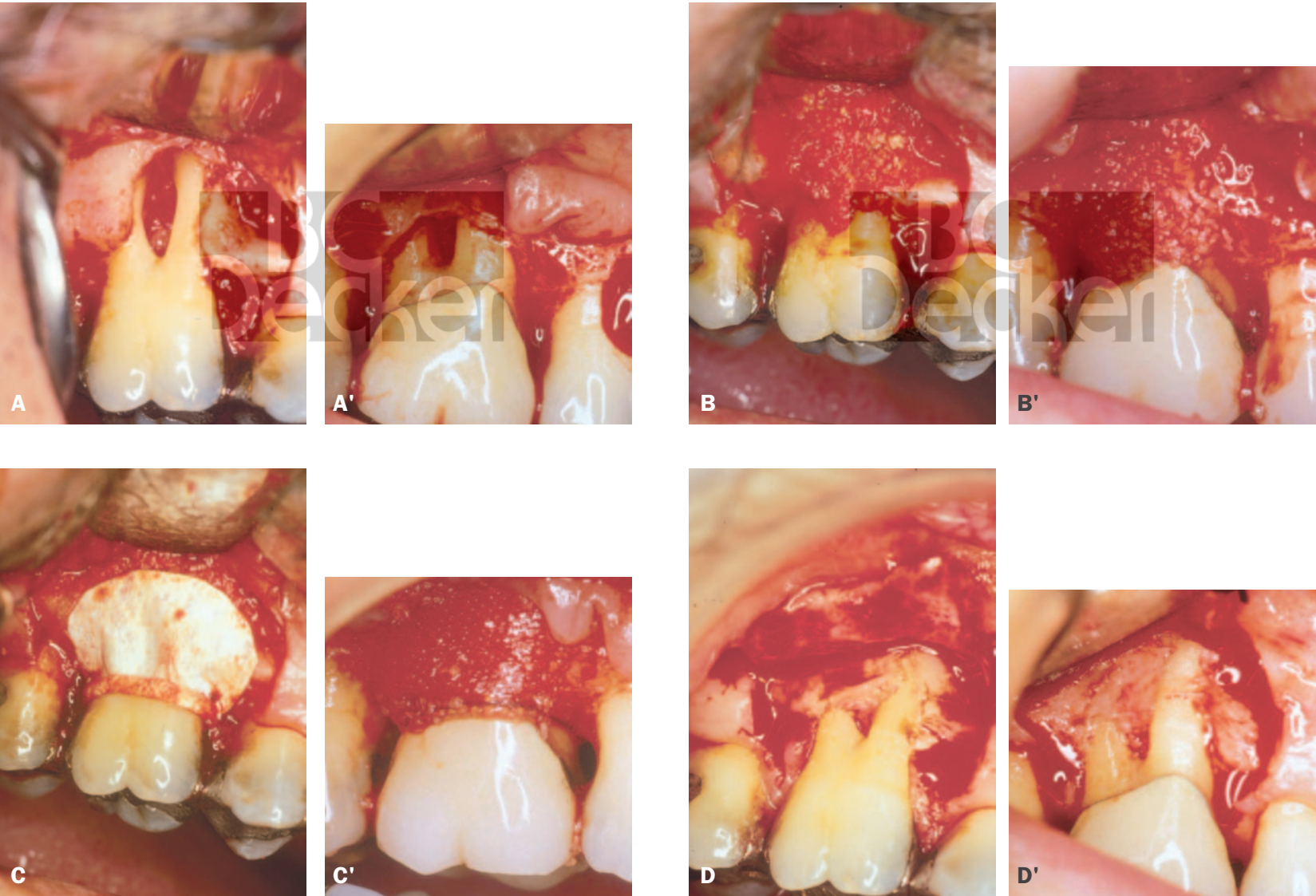


FIGURE 11-10. Guided tissue regeneration for Grade II furcations treated with nonresorbable and resorbable membranes. A, A', Before showing Grade II furcations. B, B', DFDBA placed. C, Nonresorbable (Gore-Tex) membrane placed. C', Resorbable vicryl mesh membrane. D, D' Reentry 1 year later. Note complete fill of furcations.

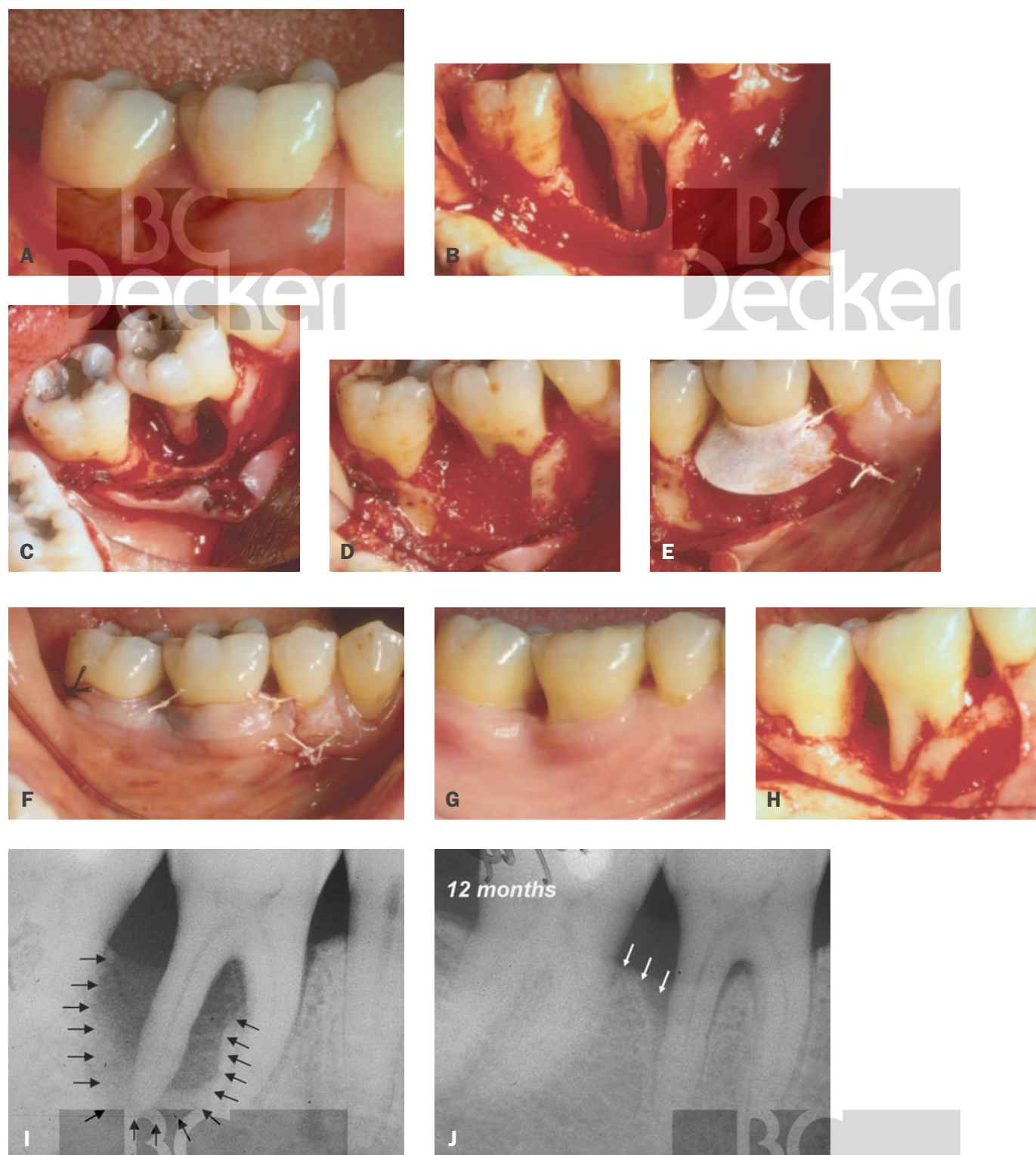


FIGURE 11-11. Guided tissue regeneration (grade III furcation). *A*, Before treatment. *B*, Grade III furcation and distal defect exposed. *C*, Occlusal view of a circumferential defect about the distal root. *D*, Demineralized freeze-dried bone allograft placed. *E*, U-shaped expanded polytetrafluoroethylene membrane placed. *F*, Flap repositioned with Gore-Tex sutures. *G*, One year later. *H*, Reentry after 1 year. Note complete fill of the furcation and significant coverage of the distal root with bone. *I*, Before treatment radiograph study. *J*, Radiograph study showing bone regeneration of furcation. A small residual distal defect remains.

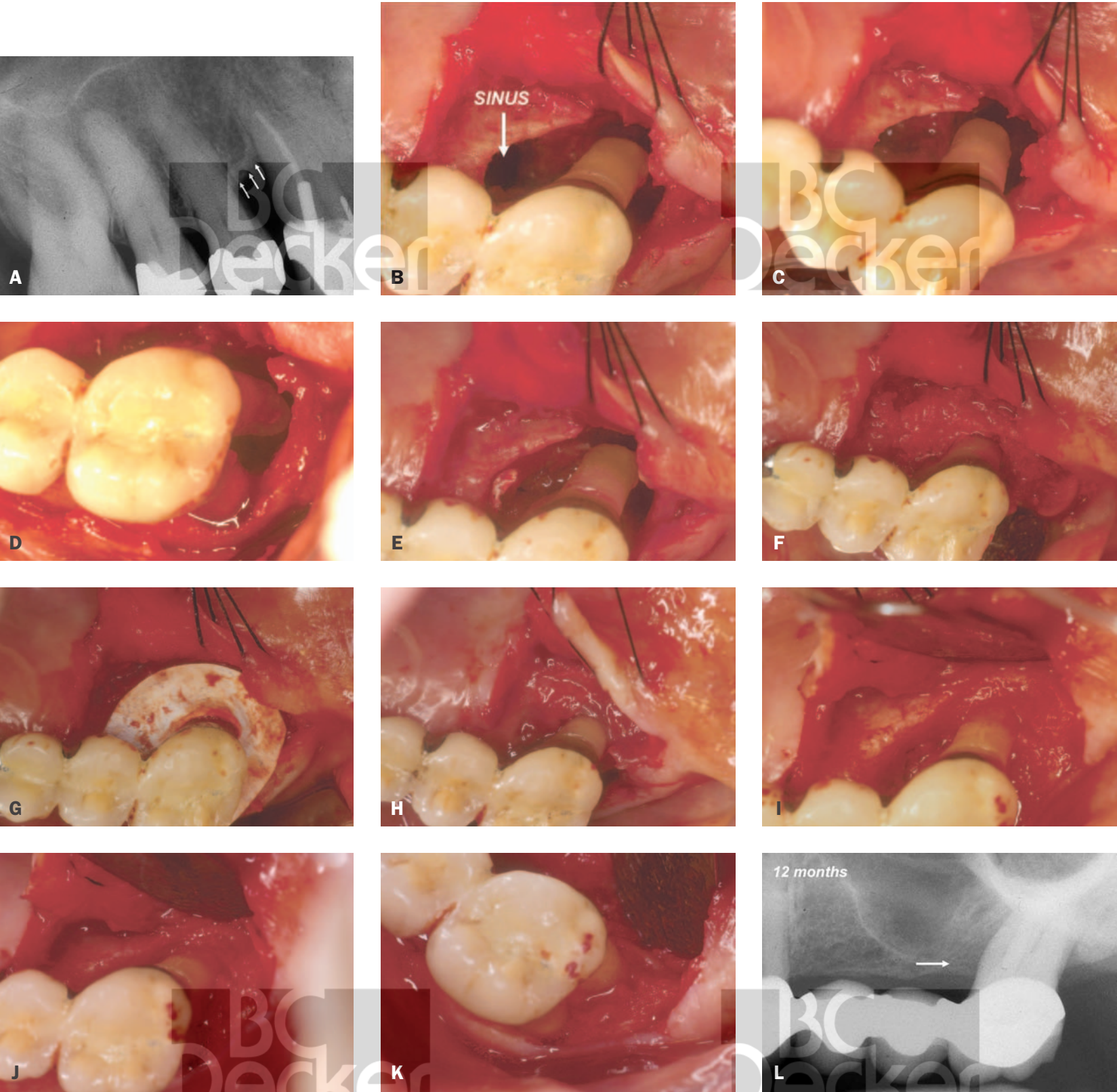


FIGURE 11-12. Guided tissue regeneration for treatment of complex periodontal problems. *A*, Preoperative x-ray indicating deep intrabony defect. *B*, Occlusal view showing sinus opening. *C*, Occlusal view showing GT III mesial furcation with no palatal bone. *D*, Distal view showing GR III distal furcation. *E*, Colatape placed into sinus opening. *F*, Defect filled with DFDBA. *G*, Nonresorbable Gore-Tex membrane positioned. *H*, Membrane removed 4 months later. Note new granulation tissue. *I*, *J*, and *K*, Re-entry showing complete fill of mesial and distal furcations coverage of sinus and fill. *L*, Final x-ray 1 year later.

Resorbable Membranes

The ideal resorbable membrane should have the following characteristics while allowing GTR to take place:

1. Biocompatible
2. Physiologically biodegradable (ie, hydrolysis)
3. Biologically inert
4. Breakdown products should be nonreactive
5. It should not promote foreign body or allergic reactions
6. Resorption rate should not vary (exposed vs unexposed)
7. Resorption should be 100%

Numerous review studies (Bunyaratavaj and Wang, 2001), a meta-analysis (Murphy and Gun-solley, 2003), and the AAP position paper on regeneration (2005) found that there are no differences between resorbable and nonresorbable membranes. The AAP paper stated that “evaluations of both polyactic acid and collagen membranes have reported clinical improvements similar to those achieved with non-resorbable membranes” and that comparable results have also been shown with degradable polymers of PLA, PGA, and mixtures of PLA and PGA.

Table 11-1 shows some of the commercially available collagen and synthetic membranes.

The clinical procedures are depicted in Figures 11-13 to 11-15. See also Chapter 9 (Xenografts) for further examples.

Ridge Augmentation. Today, although the clinician may choose a resorbable or nonresorbable

membrane for bony ridge augmentation or guided bone regeneration (GBR), e-PTFE (G-TAM®, [W.L. Gore Inc, Flagstaff, Arizona]), is still the gold standard. It is the material of choice when either space maintenance or vertical ridge augmentation are required. Titanium reinforced e-PTFE is the only material capable of providing these functions. Resorbable membranes are recommended only when membrane support is present (moderate horizontal bone deficiencies), space maintenance is not required (sinus bone augmentation procedures)(Figure 11-16) and primary closure is achieved (Javanovic 2004). In selecting a resorbable membrane, the clinician must choose one with proven histologic evidence of long term resorption.

Note: If exposure is expected, a nonresorbable membrane is recommended.

G-TAM has the ability to achieve ridge preservation and enhancement following extractions (Nevins and Mellonig 1992, Javanovic and Buser 1994, Buser et al 1990) for vertical ridge augmentation (Simion et al 2001). It is important to note that implants placed into augmented bone are successful as those placed into natural bone (Fiorellini and Nevins 2003).

Material. GTAM has two distinct portions: (1) an inner occlusive portion (with or without titanium reinforcement), which is sufficiently stiff to permit space making, and (2) an outer portion, which allows for greater connective tissue integration, promoting clot stability and epithelial inhibition (see Figure 11-5).

Defect Selection. The defects selected may or may not be associated with implants.

Osseous Defects.

1. Residual defects
2. Extraction sockets

Peri-implant Defects.

1. Fenestration
2. Dehiscence
3. Intraosseous
4. Extraction sockets—fresh and residual
5. Peri-implantitis

Predictability. Predictable success is based on achieving and maintaining adequate space between the defect and e-PTFE. This is achieved naturally in intraosseous defects or by a space filler such as DFDBA (Figures 11-18 and 11-19). Buser (1991, 1993) and Javanovic (2004) advocated the use of stainless steel screws for material stabilization and shape maintenance (Figure 11-23).

1. Most predictable: defects within the bone envelope
 - a. Dehiscence
 - b. Fenestration
 - c. Fresh extraction sites
 - d. Localized ridge augmentation
2. Moderate predictability: defects outside the bone envelope
3. Low predictability: loss of crestal bone height

Contraindications. Placement is contraindicated in the presence of active infections. Defect débridement and treatment of chronic infections are necessary precursors.

Table 11-1 Resorbable Membranes

Name	Sources	Methods of Cross-Link	Main Components Rate*	Resorption	Company
Collagen membranes					
BioGide	Porcine dermis	None	Type I and III collagen	24 wk	Osteohealth, Shirley, NY
RCM ⁶	Bovine tendon	Formaldehyde	100% type I collagen	26–38 wk	Ace Surgical Supply, Brockton, MA
BioMend	Bovine tendon	Formaldehyde	100% type I collagen	6–8 wk	Sulzer Calcitek, Carlsbad, CA
Bio-Mend-Extend	Bovine tendon	Formaldehyde	100% type I collagen	18 wk	Sulzer Calcitek, Carlsbad, CA
OSSIX	Bovine tendon	Formaldehyde	100% type I collagen	6 mo	3I, West Palm Beach, FL
Periogen	Bovine dermis	Glutaraldehyde	Type I and III collagen	4–8 wk	Collagen Inc., Palo Alto, CA
Paroguide	Calfskin	DPPA [†]	96% type I collagen and 4% chondroitin-4-sulfate	4–8 wk	Coletica, Lyon, France
Name	Source	Method of Resorption	Rate of Resorption (wk)	Company	
Synthetic membranes					
Resolute Adapt X	PGA/TMC	Hydrolysis	16–24	W.L. Gore & Associates	
Resolute Adapt LT	PGA/TMC	Hydrolysis	16–24	W.L. Gore & Associates	
Guidor	PLA	Hydrolysis	10–12	John O Butler	
Cytoplast (Vicryl Mesh)	Polyglactin 910	Hydrolysis	3–6	Ace Surgical Supply	
Epi-guide	PLA	Hydrolysis	10–12	THM Biomedical	
Resolute Adapt	PLA/PGA/TMC	Hydrolysis	8–10	W.L. Gore & Associates	
Adapted from Bunyaratavej and Wang (2001).					
PGA = polyglactic acid; PLA = polylactic acid; TMC =					
*Company data.					
[†] Diphenylphosphorylazide.					
⁶ Hexamethylenediisocyanate.					

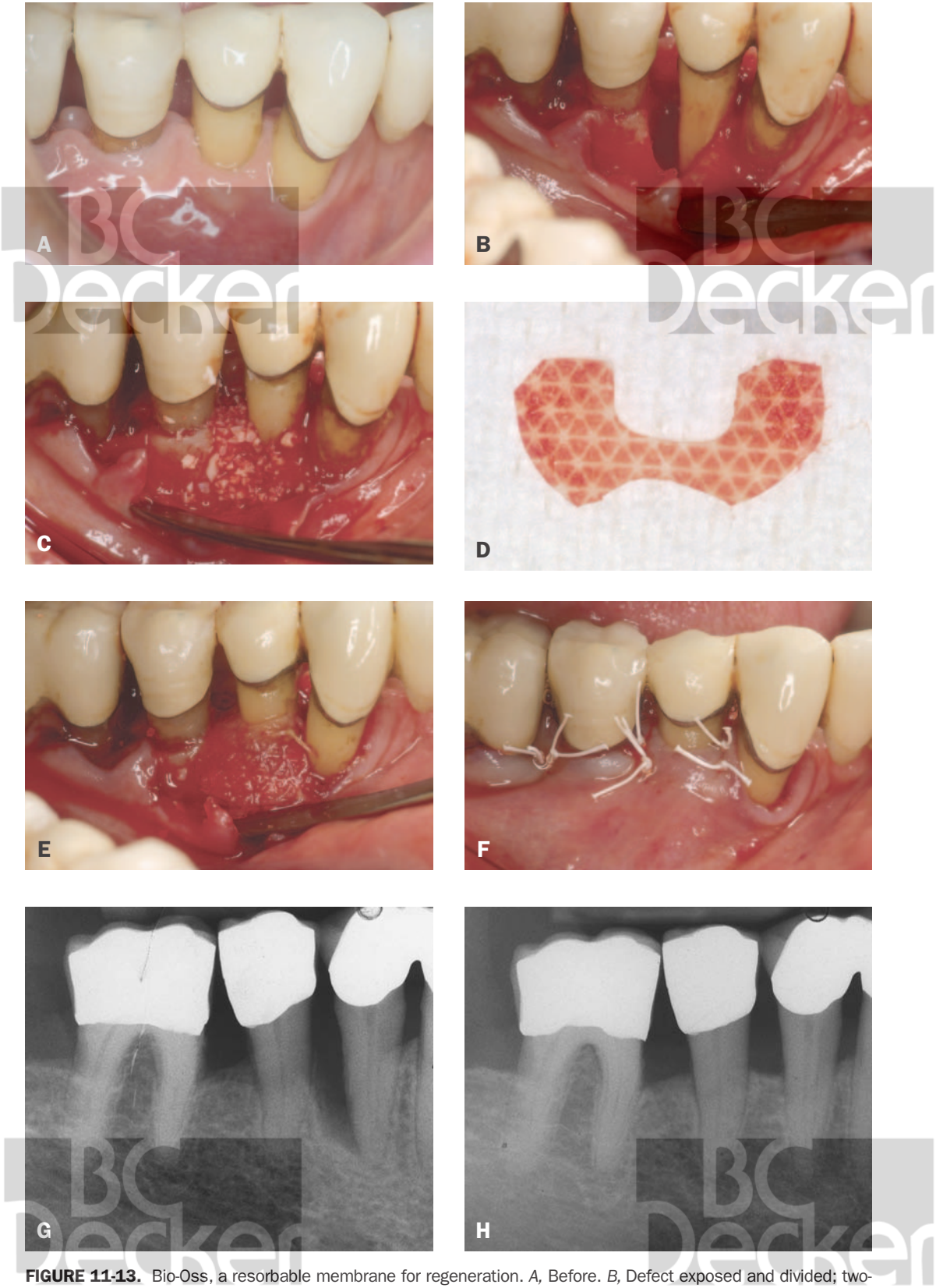


FIGURE 11-13. Bio-Oss, a resorbable membrane for regeneration. *A*, Before. *B*, Defect exposed and divided; two- to three-wall defect. *C*, Bio-Oss placed in defect. *D*, Resolute membrane contoured. *E*, Membrane sutured to position. *F*, Primary closure with Gore-Tex sutures. *G*, Starting x-ray. *H*, 1 year later with complete radiographic bone fill.

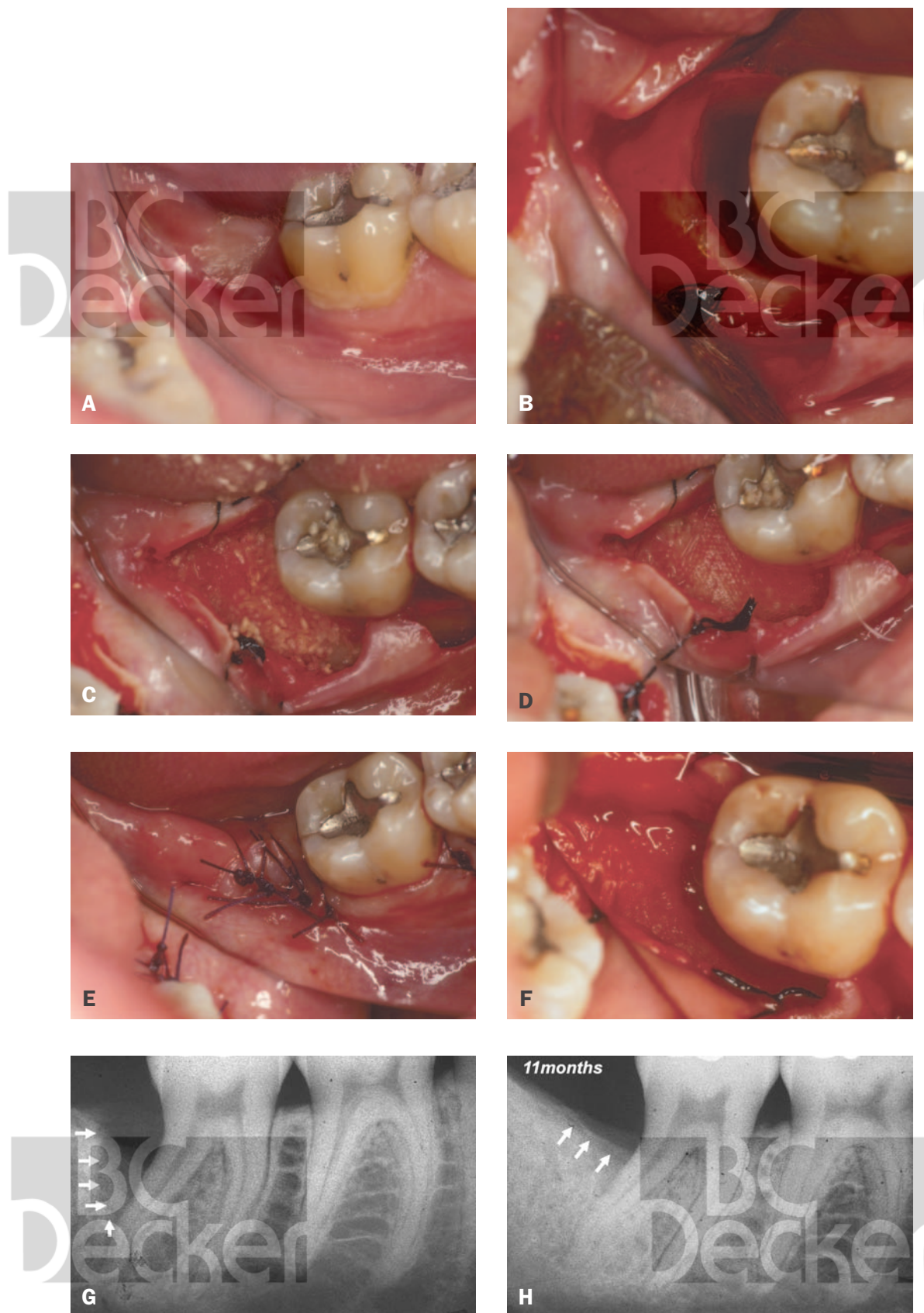


FIGURE 11-14. Guided tissue regeneration with resorbable membrane. A, Before. B, Defect degranulated; three to two wall surface defect. C, DFDBA placed. D, Resorbable membrane positioned. E, Vicryl sutures placed. F, Re-entry 11 months later. G, Preoperative x-ray.

Surgical Procedure. The surgical procedure may be a primary ridge augmentation procedure or in conjunction with implant placement (Figure 11-17).

- 1. A full-thickness mucoperiosteal flap is used for defect exposure. Flap overthinning is to

be avoided. *Thick gingival tissues enhance barrier coverage, improving results and esthetics* (Schenk et al 1994).

- 2. Incisions are extended mesially and distally far enough to ensure adequate site exposure (see Figure 11-17, A and A').
- 3. Vertical incisions (if needed) are to be posi-

tioned away from and never over the material. On the maxilla, the incisions should be made on the palatal aspect so as to ensure proper coverage of GTAM material (see Figure 11-17A').

- 4. Defects, if present, are débrided of all granulation tissue and decorticated where indicated.

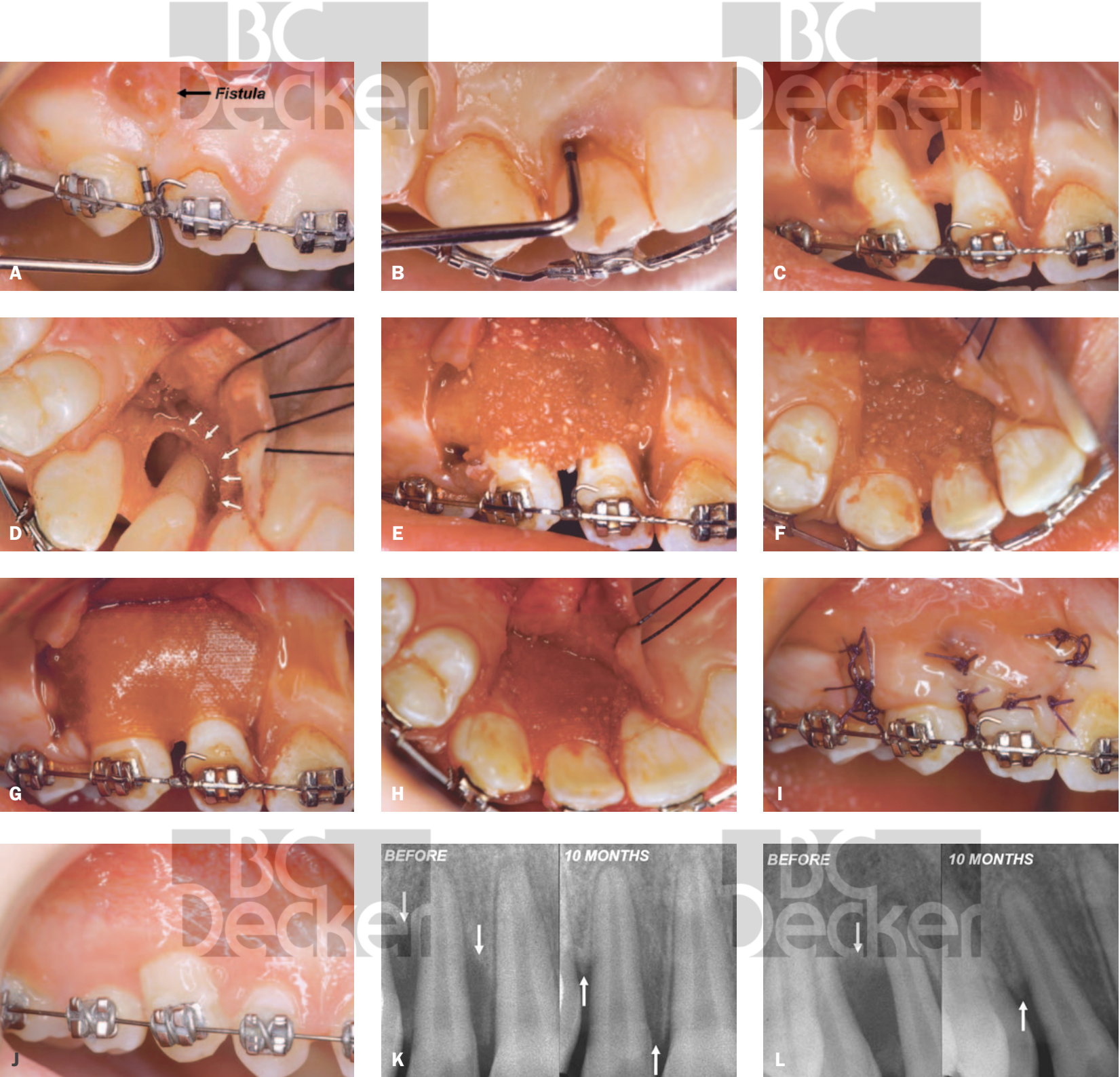


FIGURE 11-15. Guided tissue regeneration for treatment of a lateral periodontal abscess. A, Before treatment. Buccal fistula with 13-mm probability. B, Palatal view before with 13-mm probability. C and D, Buccal and palatal views showing complete blowout of bone. Arrows indicate mesial extent of defect. E and F, Buccal and palatal views of DFDBA. G and H, Buccal and palatal views of resorbable membrane positioned. I, Flap positioned and sutured. J, 10 months later. K and L, Pre- and post treatment parallel reproducible radiographs showing excellent bone regeneration.

5. DFDBA (Shallhorn and McClaine, 1988, 1993). Or BDX (Nevins et al 2003) is recommended as a spacer or filler for the defect (see Figure 11-17, D and D')
6. The material is sized and shaped so that sharp edges are avoided. The material should extend a minimum of 3 mm beyond the defect margins. The inner portion should lie over the defect (see Figure 11-17, E and E').
7. Material contact with adjacent teeth is to be avoided so as to permit sulcus development without material exposure. Two-mm of tooth clearance is recommended (see Figure 11-17E).

8. The GTAM should be properly adapted to ensure coverage of bone and graft. It should fit smoothly, avoiding folds or overlaps.
9. Stabilization is achieved by proper shaping and contouring of the material followed by good flap closure or by using implant cover screws (Becker and Becker, 1990) or mini-screws (Buser and colleagues, 1990, 1993).

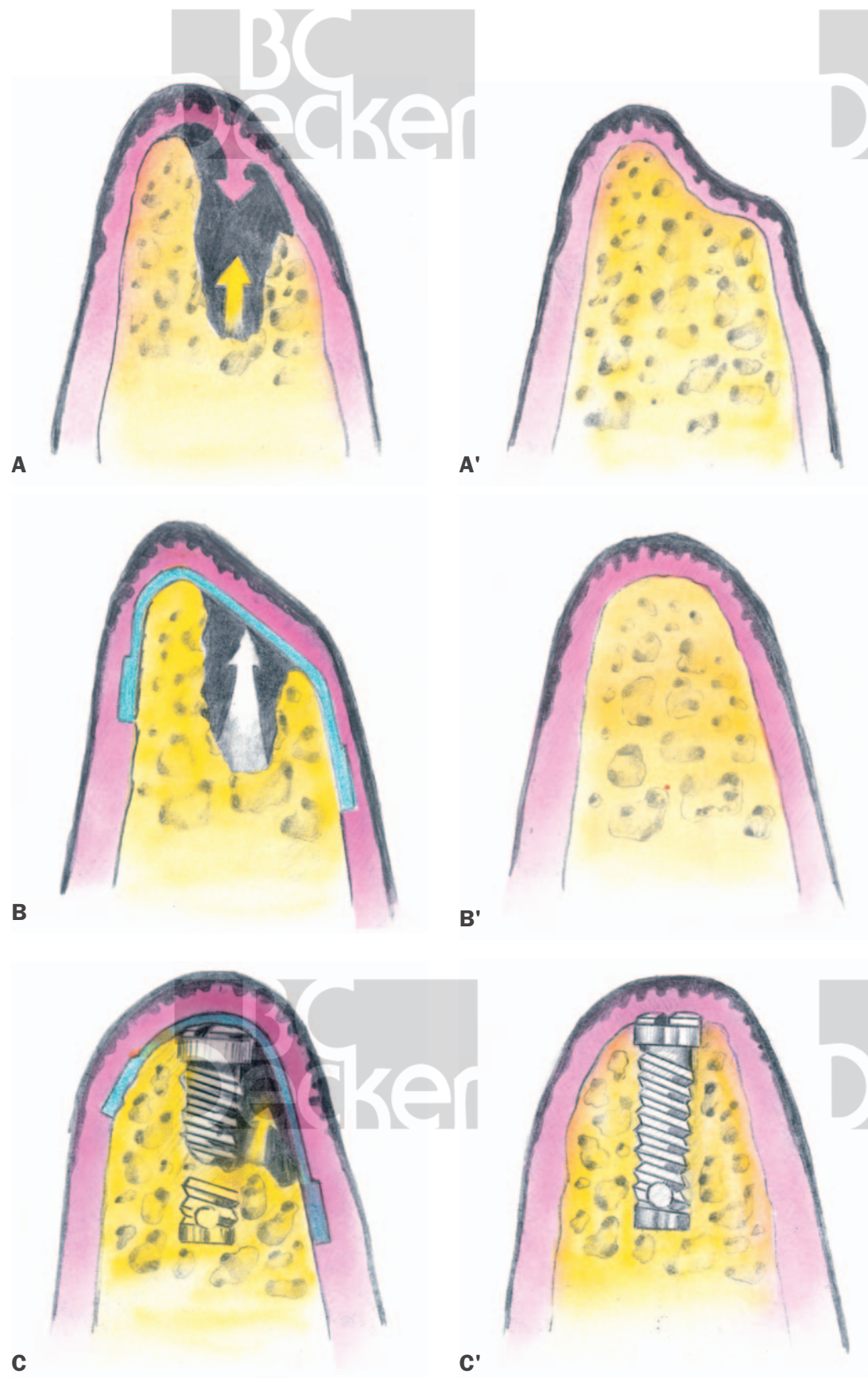


FIGURE 11-16. Guided regeneration for ridge augmentation. *A* and *A'*, Partial ridge regeneration after tooth extraction. *B* and *B'*, Complete ridge regeneration with membrane placement. *C* and *C'*, Regeneration of fenestrations, dehiscences, and sockets about immediate or delayed implant placement.

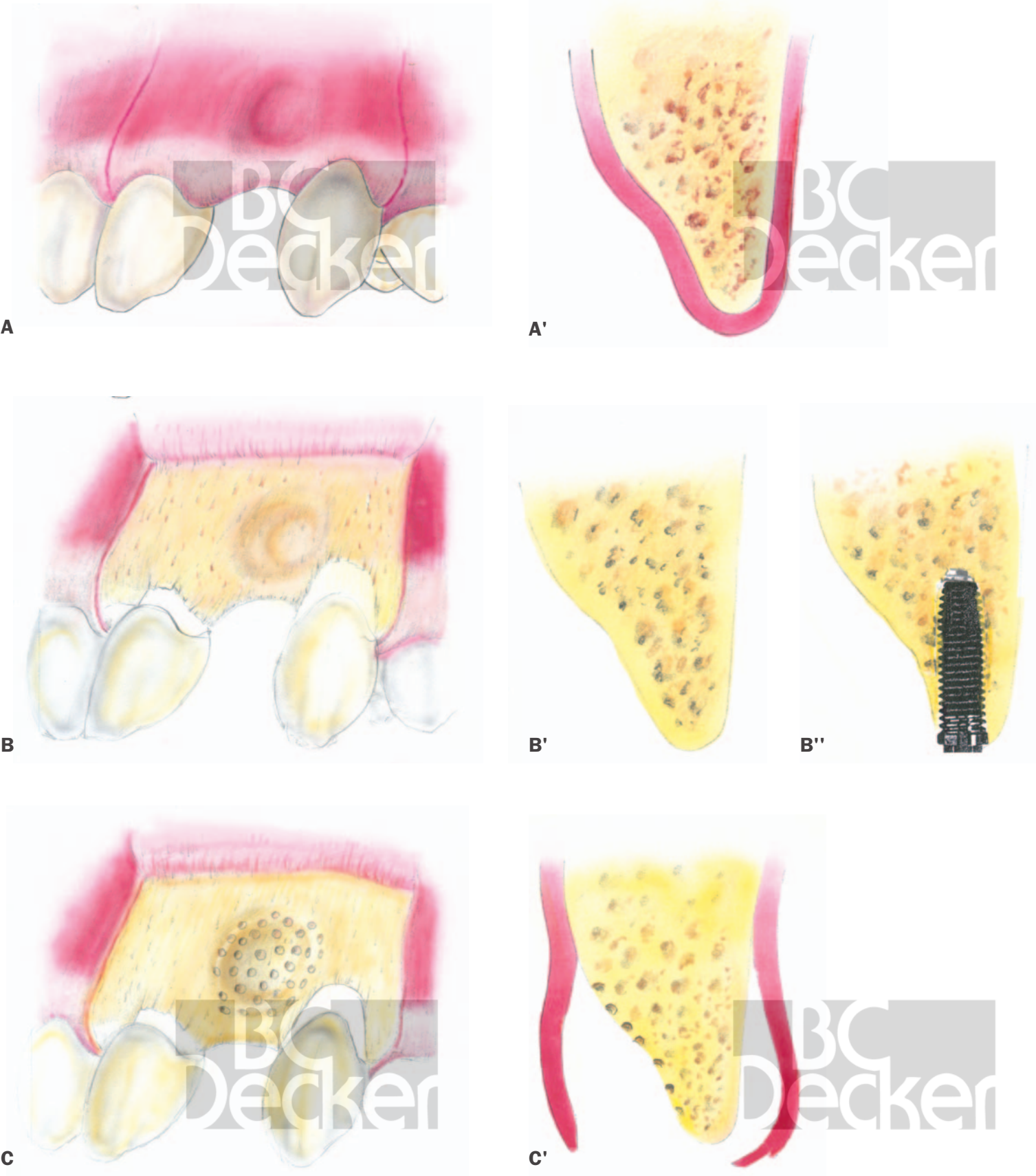
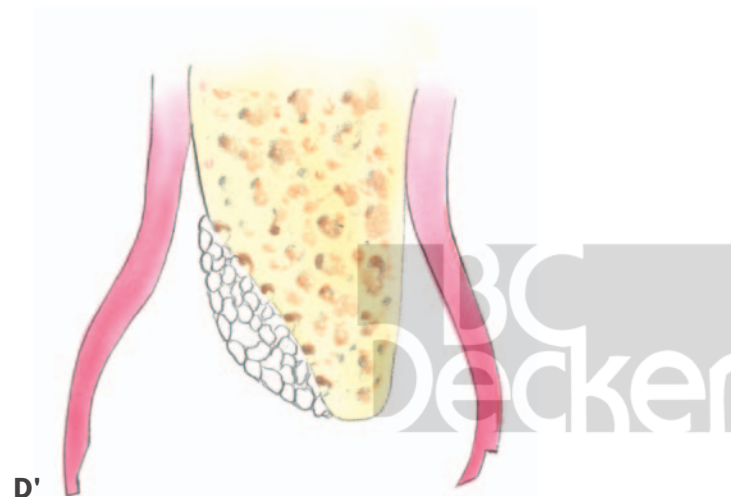


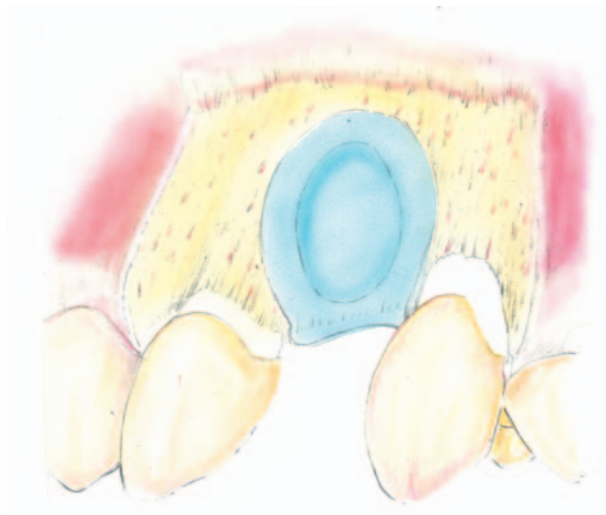
FIGURE 11-17. Ridge augmentation with guided tissue regeneration (buccal and cross-sectional views). *A* and *A'*, Incisions outlined. *B* and *B'*, Views of the ridge defect and/or implant exposure. *C* and *C'*, Decortification for bleeding. Small round holes are drilled into bone. *D* and *D'*, Graft material, usually demineralized freeze-dried bone allograft, placed in and over defects. *E* and *E'*, A Gore-Tex augmentation material membrane placed over the defect and material. The inner area must be wide enough for complete coverage. *F* and *F'*, Final suturing. Primary coverage is desired.



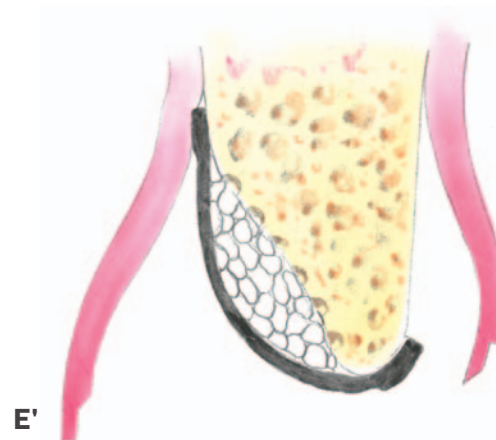
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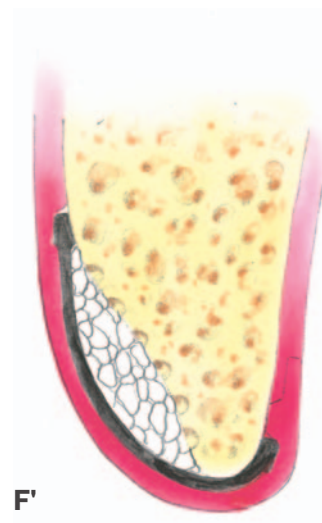
E



E'



F



F'



F''

- 10. Simple interrupted nonabsorbable Gore-Tex sutures are recommended, and primary closure is desirable (see Figure 11-17, F and F').
- 11. If unexposed, the material may remain in place from 1 to 9 months or until the time of implant exposure or placement.
- 12. Material exposure will require weekly supervision and immediate removal if any complications or infections develop. No attempt should be made to recover the material owing to bacterial contamination.

The clinical procedures are depicted in Figures 11-18 to 11-25.

GTAM Postoperative Considerations. It is important to note that the postoperative considerations differ markedly from those used for periodontal applications.

Immediate Follow-Up Care.

- 1. Maintain good oral hygiene.
- 2. Avoid denture wear if possible for the first 2 weeks.

- 3. In patients who wear dentures, the denture should be adequately relieved to avoid undue pressure, thus preventing material collapse into the defect space and avoiding unnecessary flap perforation and material exfoliation.
- 4. Sutures are maintained for as long as they are needed.
- 5. The patient is monitored on a biweekly basis.
- 6. The patient is given a chlorhexidine mouthwash and is put on TTC 250 mg daily for 10 to 14 days. This will help prevent bacterial infection, especially if the material becomes exposed.



FIGURE 11-18. Ridge augmentation and immediate implant placement. A, Before treatment. Note buccal vestibular concavity. B, Flap begun with palatal incision to assure complete tissue coverage. C, Occlusal view of implant positioned. Note buccal dehiscence. D, DFDBA placed. E, GTam 5 membrane positioned. F, Flap repositioned and sutured with Gore-Tex sutures. Note complete bony implant coverage and correction of buccal dehiscence at the time of implant exposure. G, Implant exposed. H, Final prosthetics. Courtesy of Richard Shanamen, Reading, PA.

GTAM Removal.

1. The material is removed immediately if complications develop or the edge of the material becomes exposed. Exposure of the material edge may permit bacterial wicking into the defect.
2. GTAM has been designed to act as a temporary barrier to the epithelium and connective tissue, with an optimum removal time of 1 to 9 months.
3. Early versus late removal: Early removal, although having the advantages of less patient follow-up, easier compliance, and less potential for complications, has the disadvantages of the regeneration being less mature, the need for an additional surgery, and the possibility of implant compromise. Late removal has the advantages of a longer regeneration time, avoidance of additional

surgery, and better evaluation of the result. The main disadvantages are a longer patient monitoring time and more difficult removal of the material.

Material Exposure. If the material becomes exposed, the following steps should be taken:

1. Monitor the patient weekly.
2. Use a chlorhexidine mouthwash.
3. Have the patient gently swab the area.
4. Avoid mechanical trauma because movement may disrupt regenerating tissues.
5. Remove the material immediately if the edge becomes exposed.
6. Do not attempt to recover the material.

Note: Once the material is exposed, it is to be removed in 2 months maximum.

Complications. The clinician must decide at the time of any complication if removal is indicated and if removal will facilitate resolution of the complication.

1. Infection
2. Flap slough
3. Perforation
4. Abscess formation
5. Bone loss
6. Pain
7. Soft tissue irregularities
8. Flap perforation
9. Material exfoliation

Evaluating Results.

1. Radiograph 6 to 12 months postoperatively
2. Clinical evaluation at the time of material removal (if early) or at the second-stage implant procedure

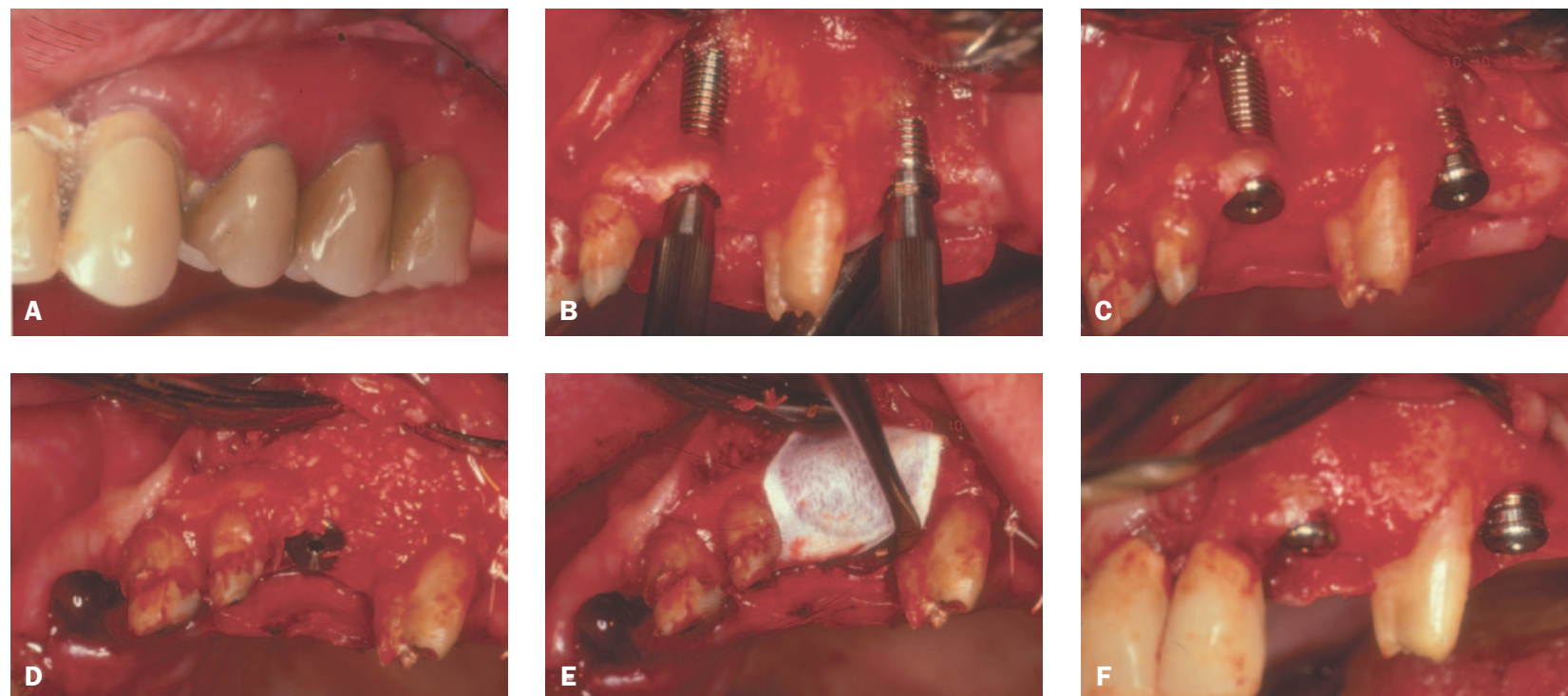


FIGURE 11-19. Ridge augmentation and immediate implant placement. A, Before treatment. B, Implants placed with paralleling cones. Note almost complete buccal dehiscences. C, Implants with screw covers. D, DFDBA placed. E, GTAM positioned. F, Re-entry after 6 months. Note complete coverage of implant threads. Courtesy of Dr. Richard Shanaman, Reading, PA.

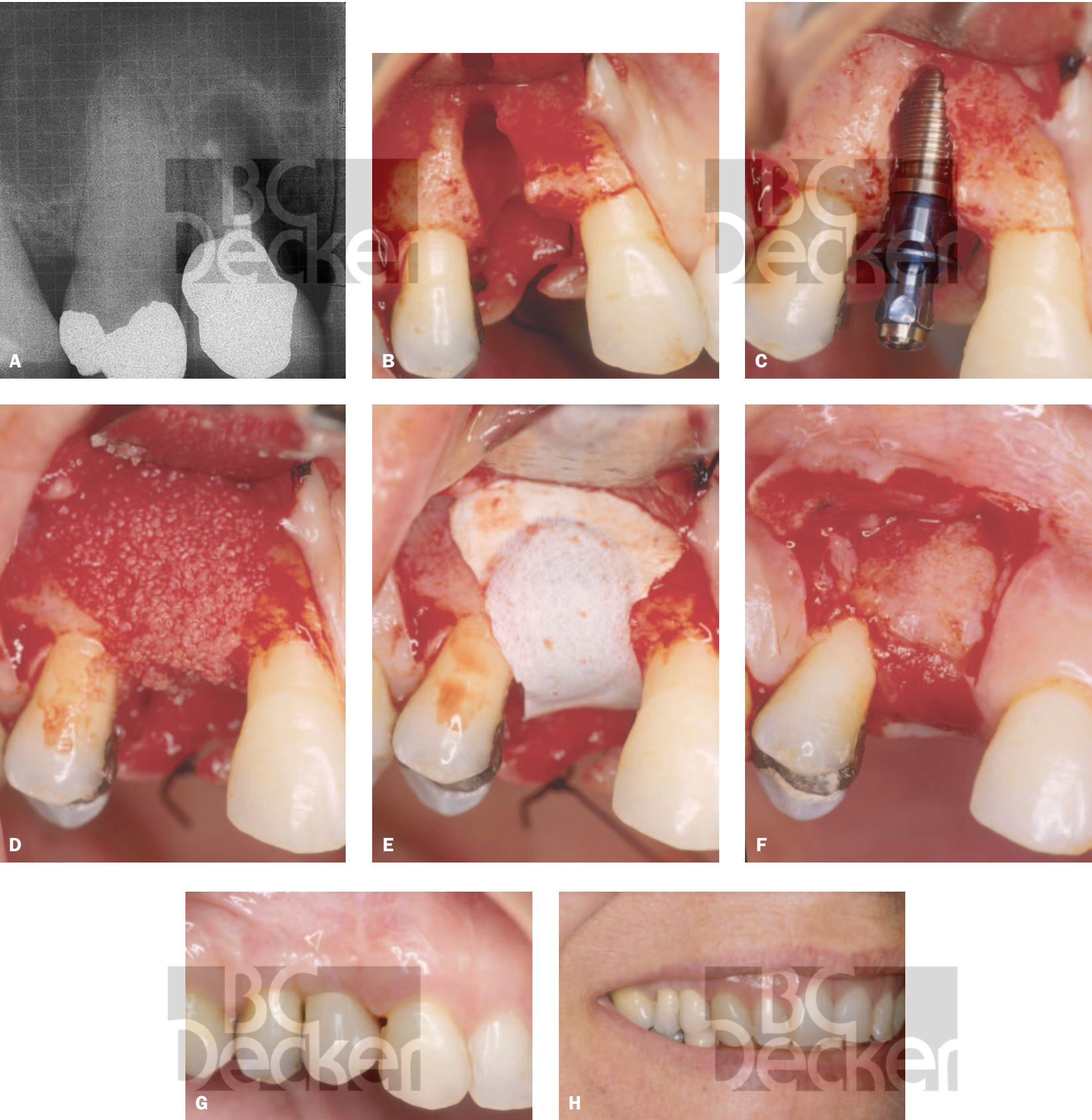


FIGURE 11-20. Extraction with immediate implant placement. A, Preoperative radiographic view showing endodontic failure. B, Extraction and degranulation of defect. C, Implant placed 1–3 mm below crest of bone. D, DFDBA. E, e-PTFE membrane Gore-Tex positioned. F, Membrane removal 6 months after showing complete regeneration. G, Final prosthetics showing excellent result. H, Note excellent clinical result with high smile line.

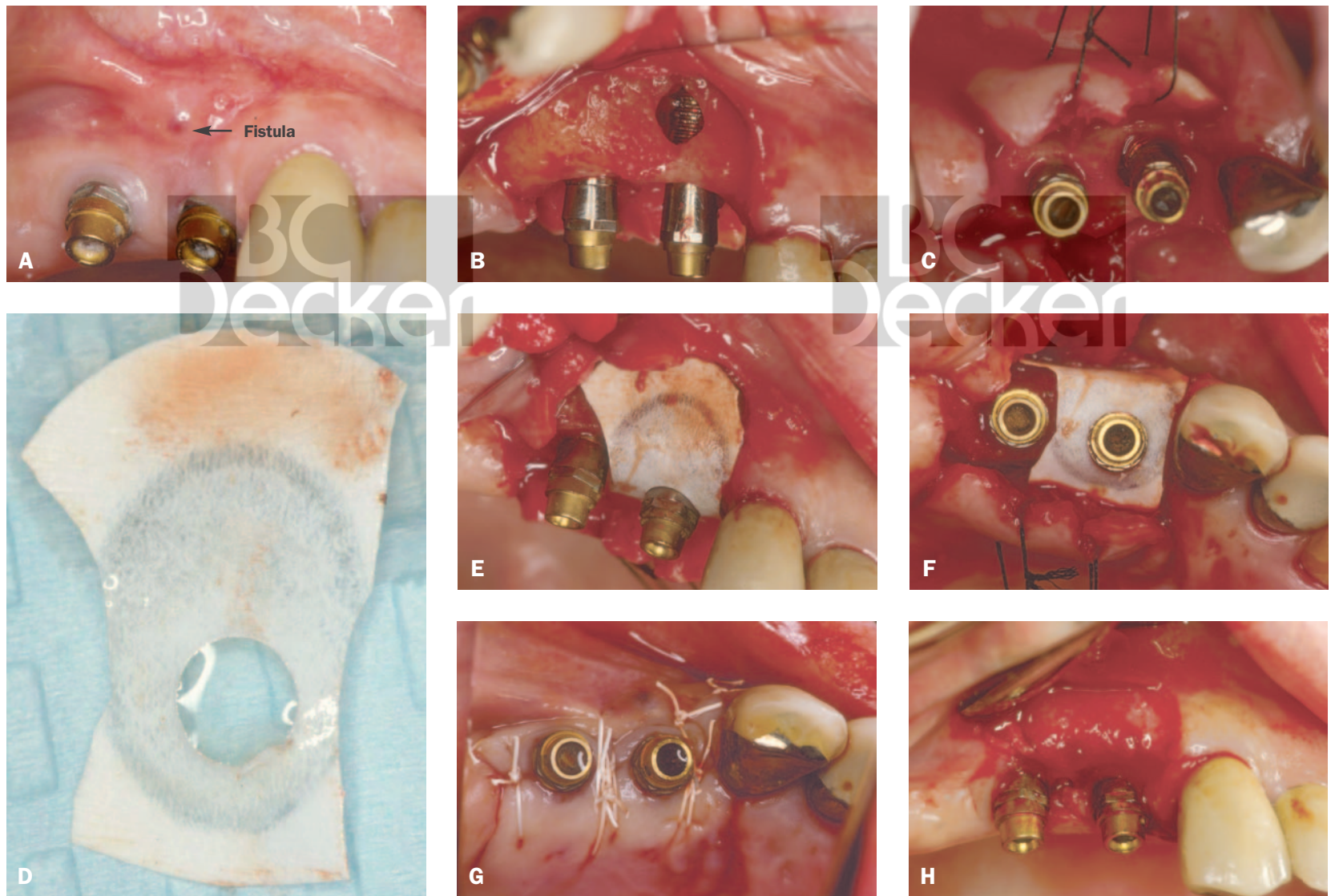


FIGURE 11-21. Peri-implant infection treated by guided tissue regeneration. A, Before. B, Buccal and C, occlusal views showing peri-implantitis. D, Membrane with hole to fit over implant. E, Buccal and F, occlusal views of implant placement after DFDBA.

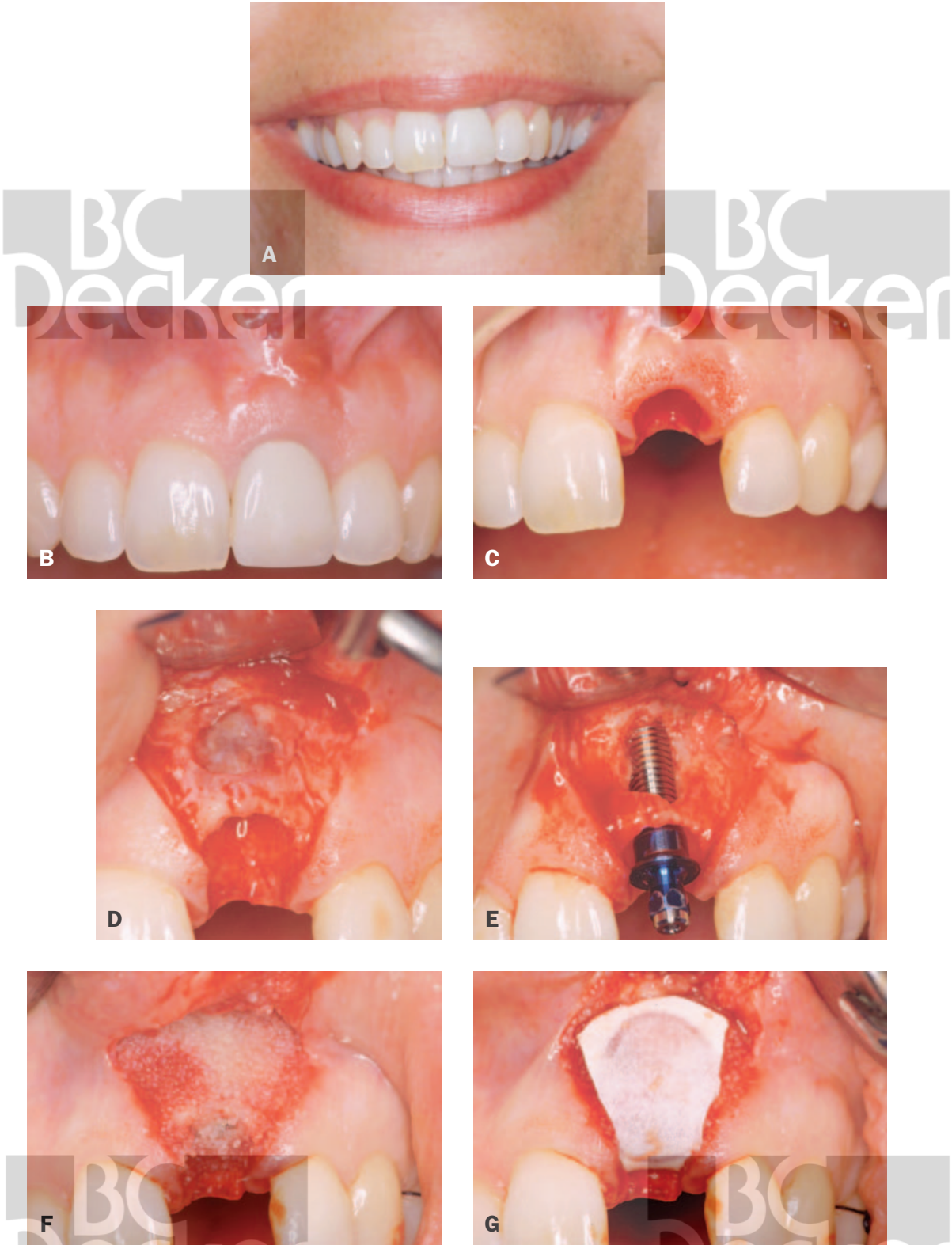


FIGURE 11-22. Extraction and immediate implant placement combined with connective tissue graft. *A*, Before showing high smile line. *B*, Before close up view. *C*, A traumatic tooth removal. *D*, Flap reflected without papillary involvement. *E*, Abscess removed and implant placed. Note preservation of crestal bone. Implant was indexed at time of placement. *F*, DFDBA placed. *G*, Gore-Tex membrane placed.

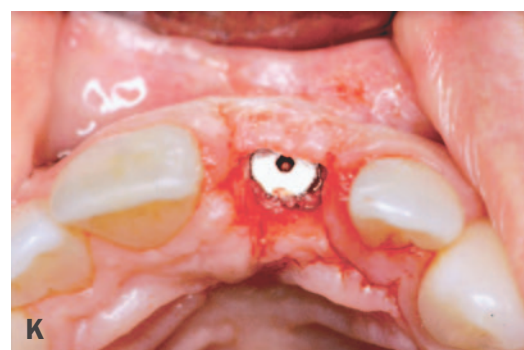
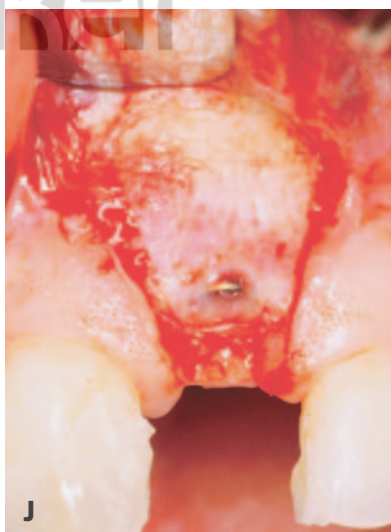
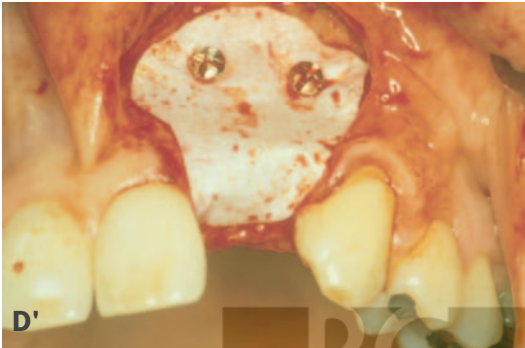
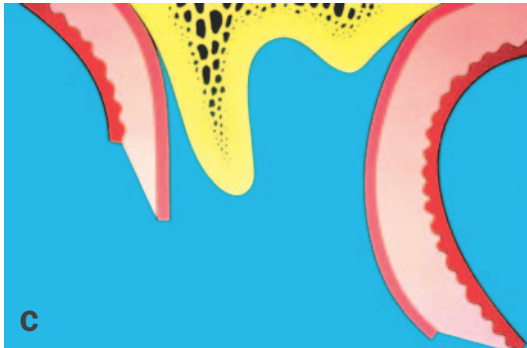
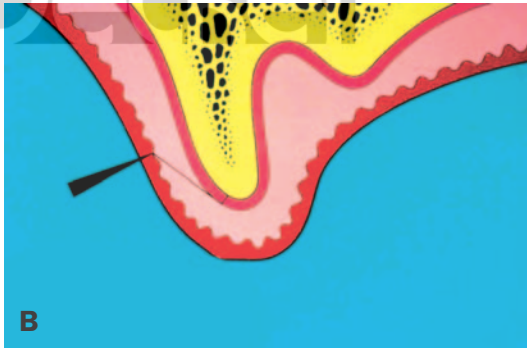


FIGURE 11-22. Continued. *H*, CT graft placed over. *I*, Flap repositioned and sutured. *J*, Membrane removed 6 months later with complete osseous repair. *K*, Implant exposure from palate to avoid facial tissue recession. *L*, Immediate temporization provided gingival scallop. *M*, Excellent healing with complete implant head exposure. *N*, Ceramic abutment used for aesthetics. *O* and *P*, final view of smile and close up. Note excellent aesthetic result. (Prosthetic by Dr. Edward Cohen, Sharon, MA).

FIGURE 11-23. Ridge augmentation with Gore-Tex augmentation material and stainless steel positioning screws (ITI). *A*, Before treatment. *B* and *B'*, Diagrammatic and clinical views of a palatal incision. *C* and *C'*, Flags reflected. *D* and *D'*, Expanded polytetrafluoroethylene membrane positioned with stainless steel screws.



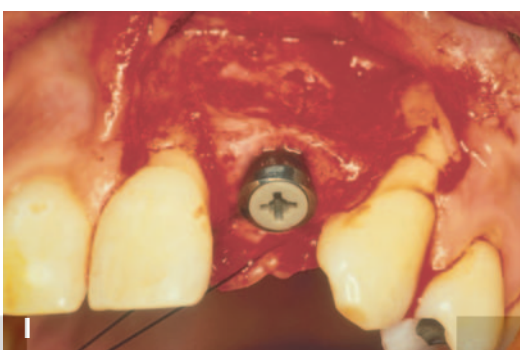
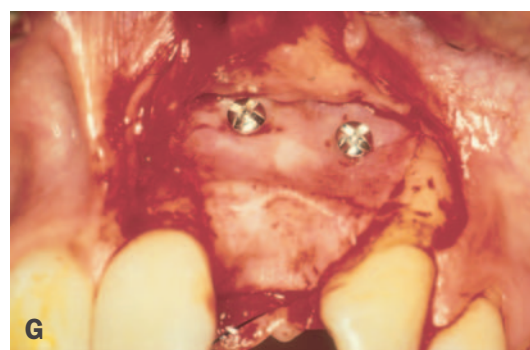
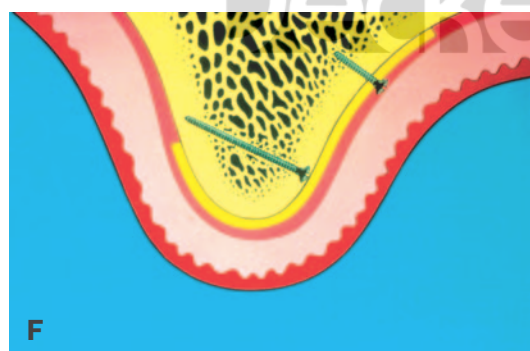
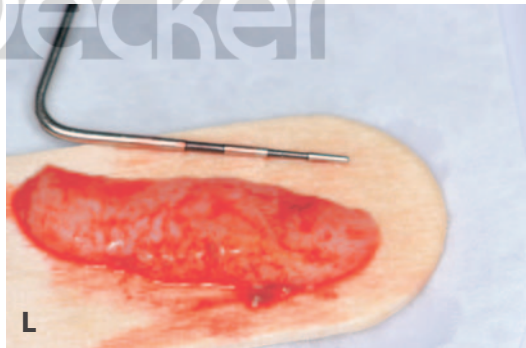
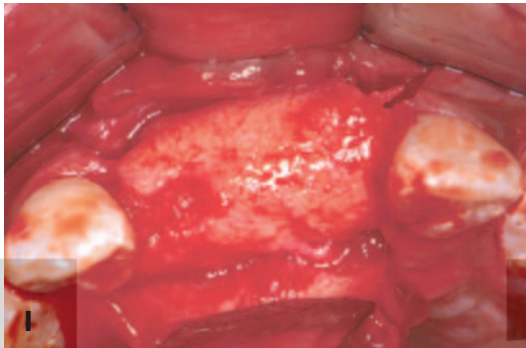
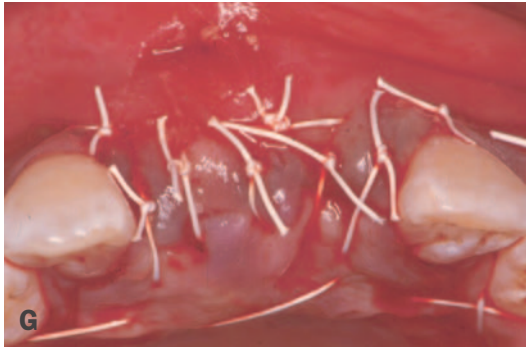
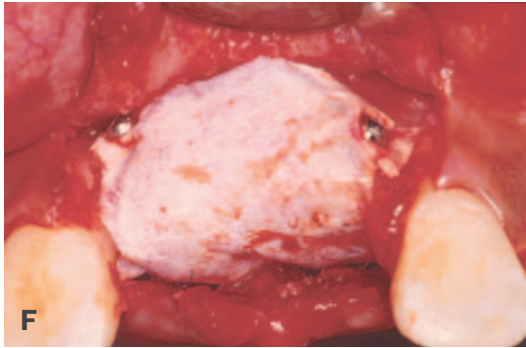
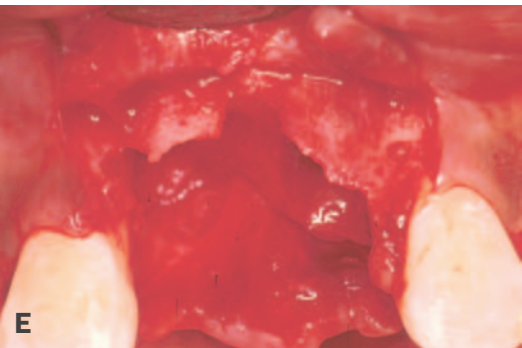
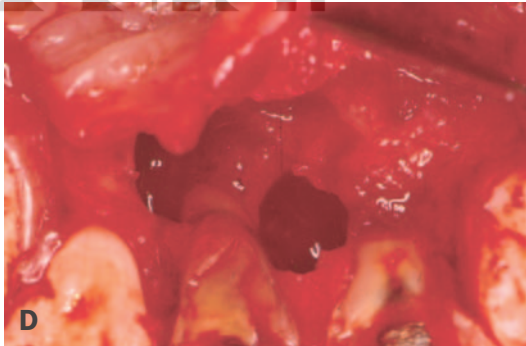
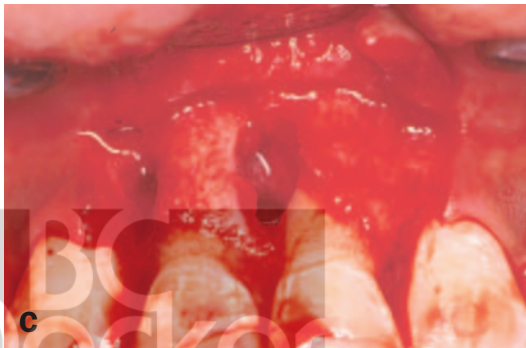


FIGURE 11-23. (continued) *E* and *E'*, Flaps reapproximated and sutured. *F* and *F'*, Complete healing at 6 months. *G*, Reentry at 6 months showing membrane and screws. *H*, Membrane removed, exposing underlying bone. *I*, Implant properly positioned. *J*, Radiograph study of the case completed. Courtesy of Daniel Buser, Bern, Switzerland.



FIGURE 11-24. A and B, Preoperative clinical and radiographic views. C and D, Buccal and palatal views of exposed defects about the teeth. E, Teeth extracted with extensive residual ridge defect. Defect outlined. F, DFDBA with large G-Tam (e-PTFE) membrane tacked in position. G, Flaps coronally sutured with e-PTFE sutures. Note primary closure. H, Healing 6 months later with excellent vertical augmentation. I, e-PTFE membrane removed 6 months later with complete bone regeneration. J, Implants positioned and indexed at 8 months. K, Final implant position. L, Connective graft taken to establish final ridge contour.



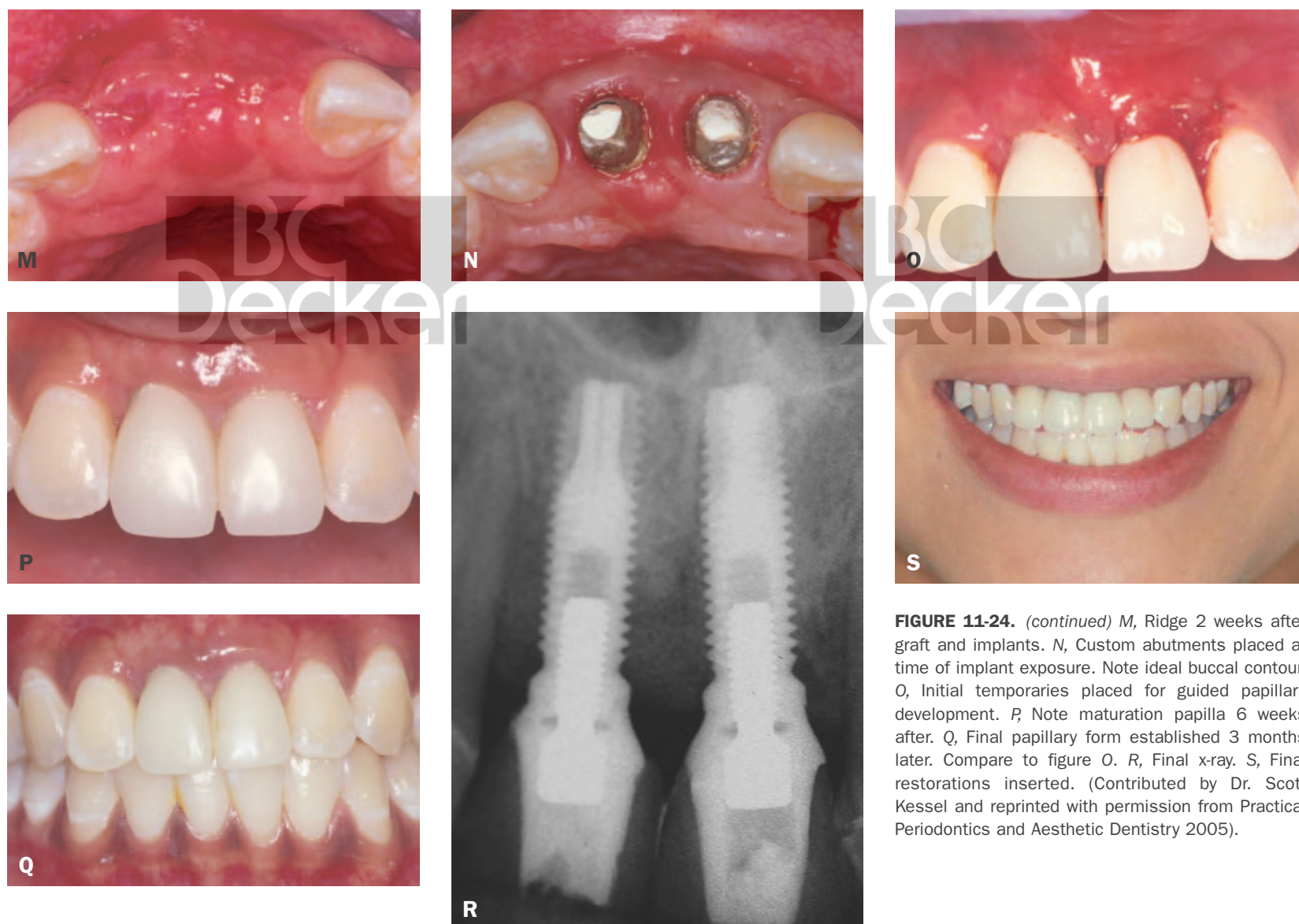


FIGURE 11-24. (continued) M, Ridge 2 weeks after graft and implants. N, Custom abutments placed at time of implant exposure. Note ideal buccal contour. O, Initial temporaries placed for guided papillary development. P, Note maturation papilla 6 weeks after. Q, Final papillary form established 3 months later. Compare to figure O. R, Final x-ray. S, Final restorations inserted. (Contributed by Dr. Scott Kessel and reprinted with permission from Practical Periodontics and Aesthetic Dentistry 2005).

Enamel Matrix Derivative

Embryonically, the ameloblasts that form Hertwig's epithelial root sheath secrete and synthesize enamel matrix proteins, resulting in the mineralization of the dentinal surface. These proteins induce mesenchymal differentiation on the root surface and formation of collagen and cementum.

Amelogenins are the most abundant component (90%) of the enamel matrix proteins. The commercially available EMD is derived from porcine enamel matrix (Emdogain, Strauman). It is a safe, nonallergenic material approved by the US Food and Drug Administration (FDA) and used to induce regeneration of the periodontal tissues: bone, cementum, and the PDL (Hammarström, 1997a, 1997b). Although used as a gel, Sculean and colleagues (2002) showed that it remains in the tissue for up to 2 weeks and on the root surface for 4 weeks.

A number of clinical studies have shown significant improvement in CAL-G and bone fill in intrabony defects when compared with controls (Heden, 1999, 2000; Tonetti and colleagues, 2002).

Pontoriero and colleagues (1999) and Silverstri and colleagues (2000) found no differences between EMD treatment and GTR. Heidi and Gestrelus (2001), in a meta-analysis of the literature for the FDA from 1998 to 2001, found that EMD was equal to or greater than other regenerative modalities. Human histologic confirmation of regeneration (bone, cementum, and PDL) was reported by Heijl (1997) and Hukna and Mellonig (2000). In a recent study of Class II mandibular furcations, Jepsen and colleagues (2003) found EMD to be equal to GTR in achieving significant improvement in horizontal clinical attachment level. Francetti and colleagues (2005) found that EMD achieved significant bone fill at 12 months of meta-analysis, especially in defects of ≥ 6 mm.

Rasperini and colleagues (2005) demonstrated that the results were stable at 7 years.

Giannobile and colleagues (2003), in a systematic meta-analysis of the literature and the AAP position paper on periodontal regeneration (2005), stated that EMD has the "potential for regenerative therapy around natural teeth and represents a novel method for enhancing regeneration outcomes." The results in intrabony defects are similar to those obtained with other regenerative modalities and are significantly better than those for OFD.

Heden and Wennström (2006) in a long-term (5 years) study on the effects of regenerative therapy following EMD in angular bony defects that the CAL gains (5.4 mm, $p < .001$) and pocket reduction (5.2 mm, $p < .001$) were stable.

Note: EMD is one of only three nonautogenous materials to show true histologic regeneration. DFDBA and Bio-Oss are the others.

Procedure

- 1. Mucoperiosteal flap elevation (Figure 11-26A)
 - a. Intrасulcular incisions (Figure 11-26B)
 - b. Maximum conservation of tissue
- 2. Degranulation of the osseous defect (Figure 11-26C)
- 3. Meticulous scaling and root planing of the root surface (Figure 11-26D)

- 4. Biomechanical demineralization of the root surface with 24% EDTA (Biora) neutral pH for 2 minutes (Figure 11-26E).

Note: EDTA will not interfere with the vitality of the surrounding tissues or denature the collagenous matrix.

- 5. The area is rinsed with saline to remove the conditioning agent (Figure 11-26F).
- 6. Hemostasis: Complete control of bleeding within the defect is critical to prevent recontamination. Hemostasis can be achieved by
 - a. Complete degranulation
 - b. A moistened saline gauze placed in the defect.

Note: The EMD gel is capable of taking up the wetness of the root while still permitting precipitation of the enamel matrix proteins.

- c. The use of local anesthetic with a vasoconstrictor should be used only in those cases of excessive bleeding.
- 7. Application of EMD (Figure 11-26, G and H). EMD is applied by means of a syringe to the exposed root surface starting at the most apical bone level. Care must be taken to ensure that the whole root is covered.

To ensure that a sufficient concentration of material remains in apposition to the root surface, the sutures may be placed but left untied. This will permit immediate flap placement and material stabilization.

Note: EMD does not act as a barrier or provide space maintenance. Therefore, it is important to cover the complete root surface to permit matrix protein precipitation.

- 8. Decortification or intramarrow penetration, if required, follows EMD application.

Note: If a graft material and/or a membrane are to be used, they are placed after the initial EMD application. The EMD can also be mixed with the graft material prior to application (Figure 11-26, I and J).

- 9. The flaps are repositioned for primary closure with monofilamentous, nonirritating, nonresorbable suturing materials. Osteoplasty or gingival trimming may be performed to facilitate flap closure (Figure 11-26, K and L).

Note: Wound stability is predicated on flap stability.

- 10. Occlusal adjustment and/or splinting are recommended in cases of excessive mobility.
- 11. Postsurgical recommendations are
 - a. Chlorihexidine gluconate (0.12%)
 - b. Doxycycline 100 mg for 10 to 21 days (Mellonig, 1999)

The clinical procedures are depicted in Figures 11-27 to 11-30.

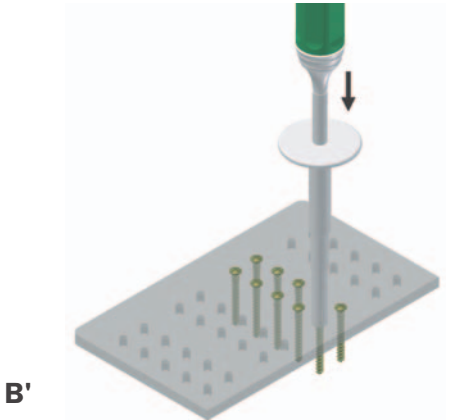
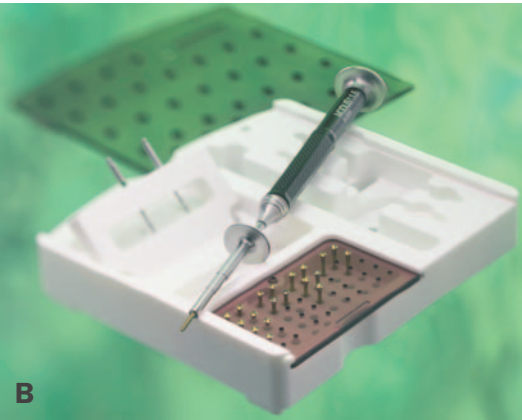
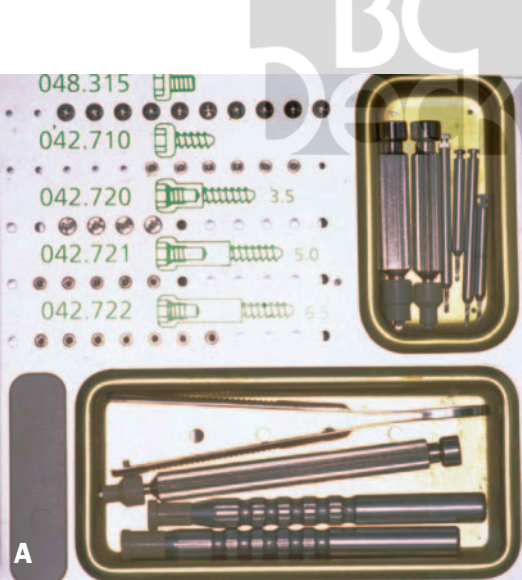
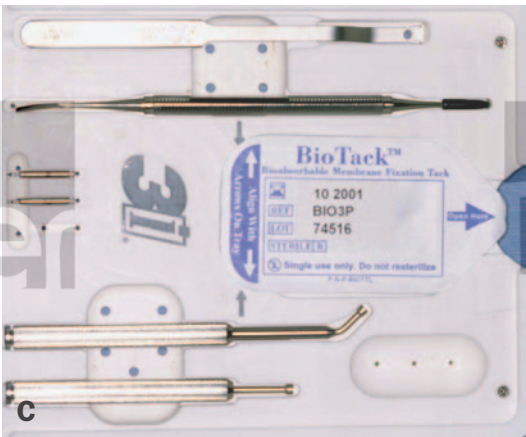
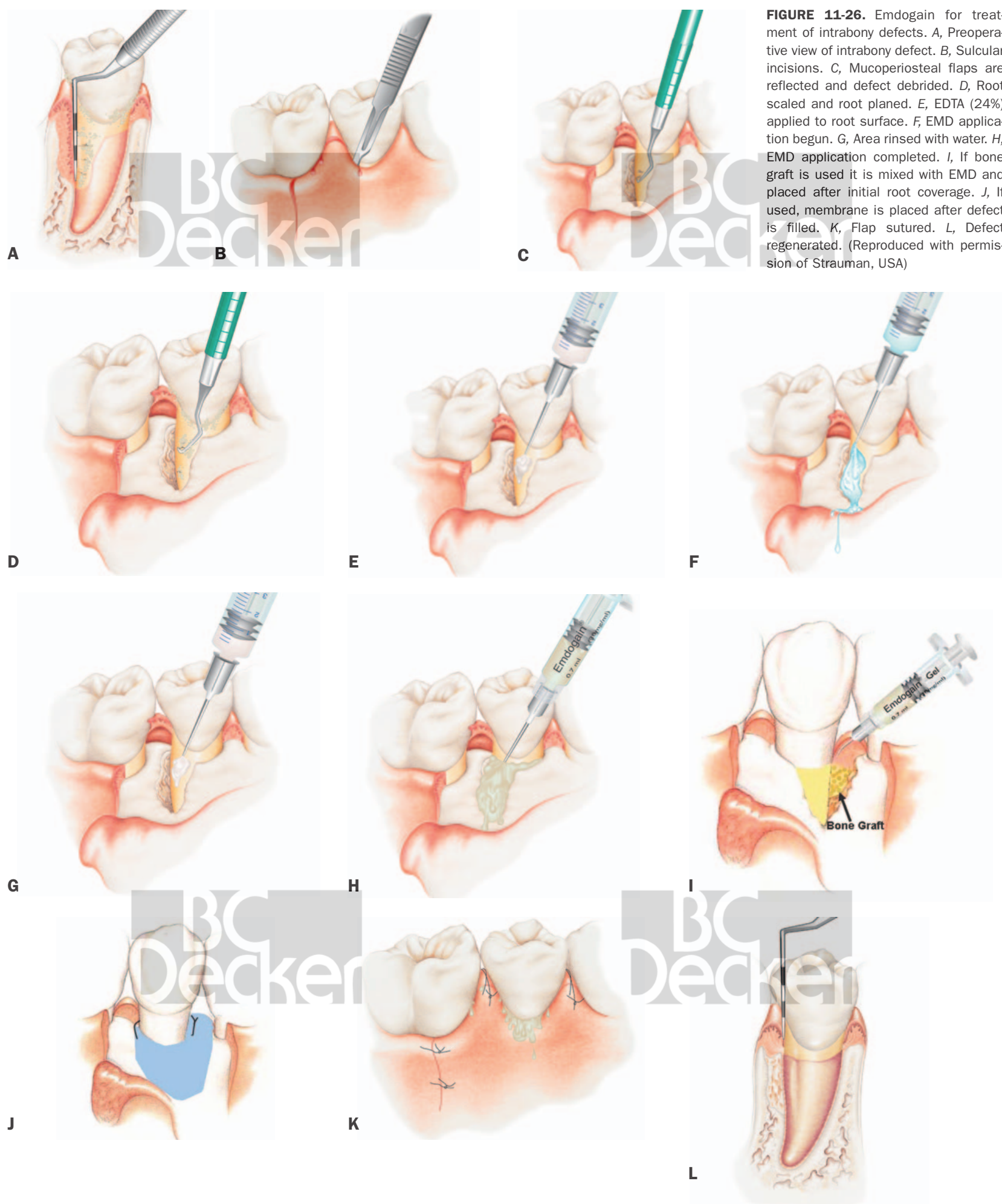


FIGURE 11-25. A and A', Memfix membrane fixation kit (Straumann, USA). B and B', Bove block fixation kit. Contributed by Straumann, USA. C, Bio-Tac resorbable membrane kit (Implant Innovations, Florida).





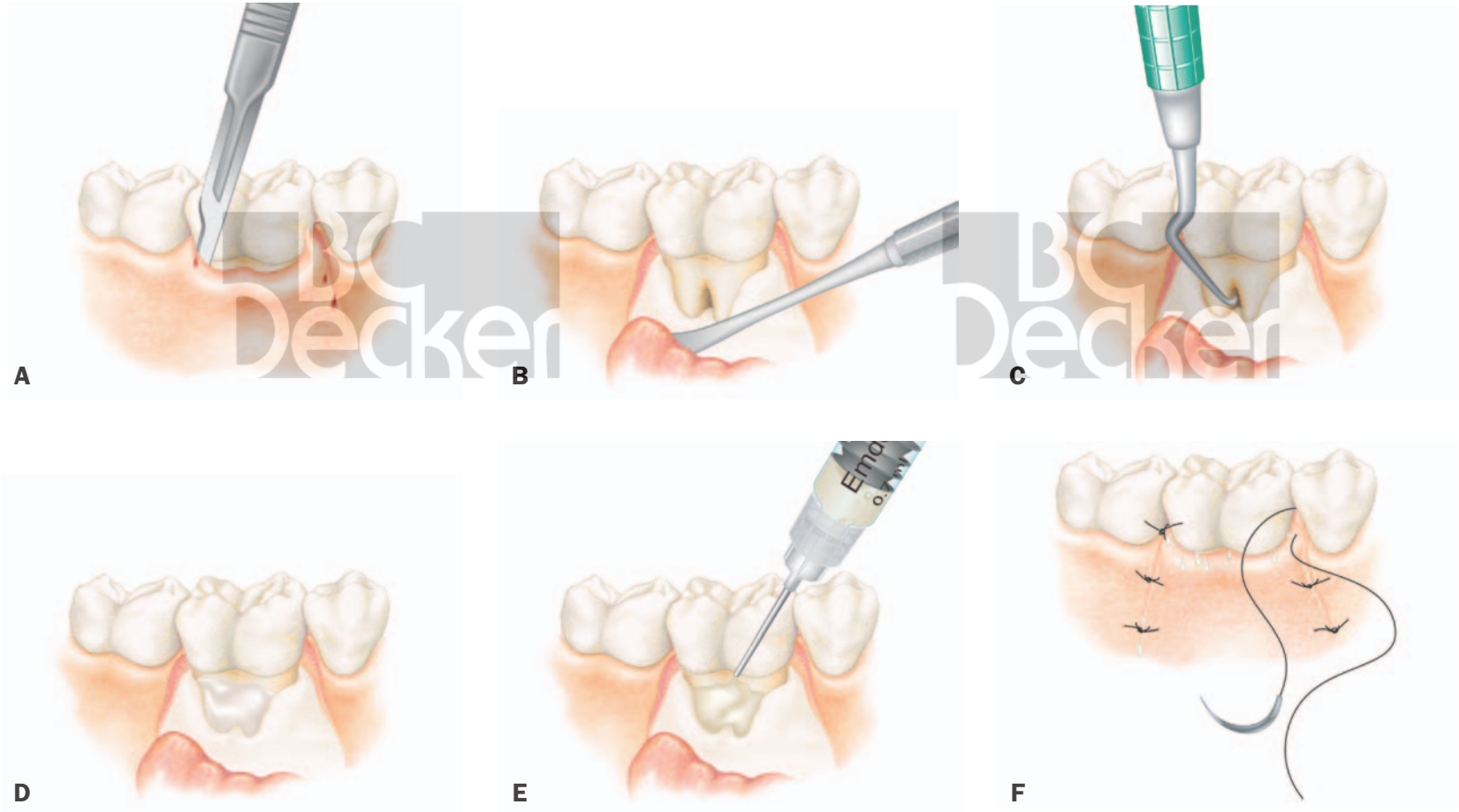


FIGURE 11-27. Emdogain for treatment of mandibular furcation. A, Sulcular incision for maximum conservation of tissue. B, A full thickness mucoperiosteal flap is elevated. C, The furcation is debrided, scaled, and root planed. D, Emdogain is placed after the EDTA. E, EMD placement complete. F, Flap repositioned and sutured. Reproduced with permission of Struman, USA.





FIGURE 11-29. A, Preoperative view. B, Root scaled and planed and EDTA applied. C, Emdogain and DFDBA with Emdogain placed. D, Modified flap sutured. E, Final healing 1 year later. F, Re-entry at 1 year. Defect eliminated but no buccal coverage due to lack of space maintenance.

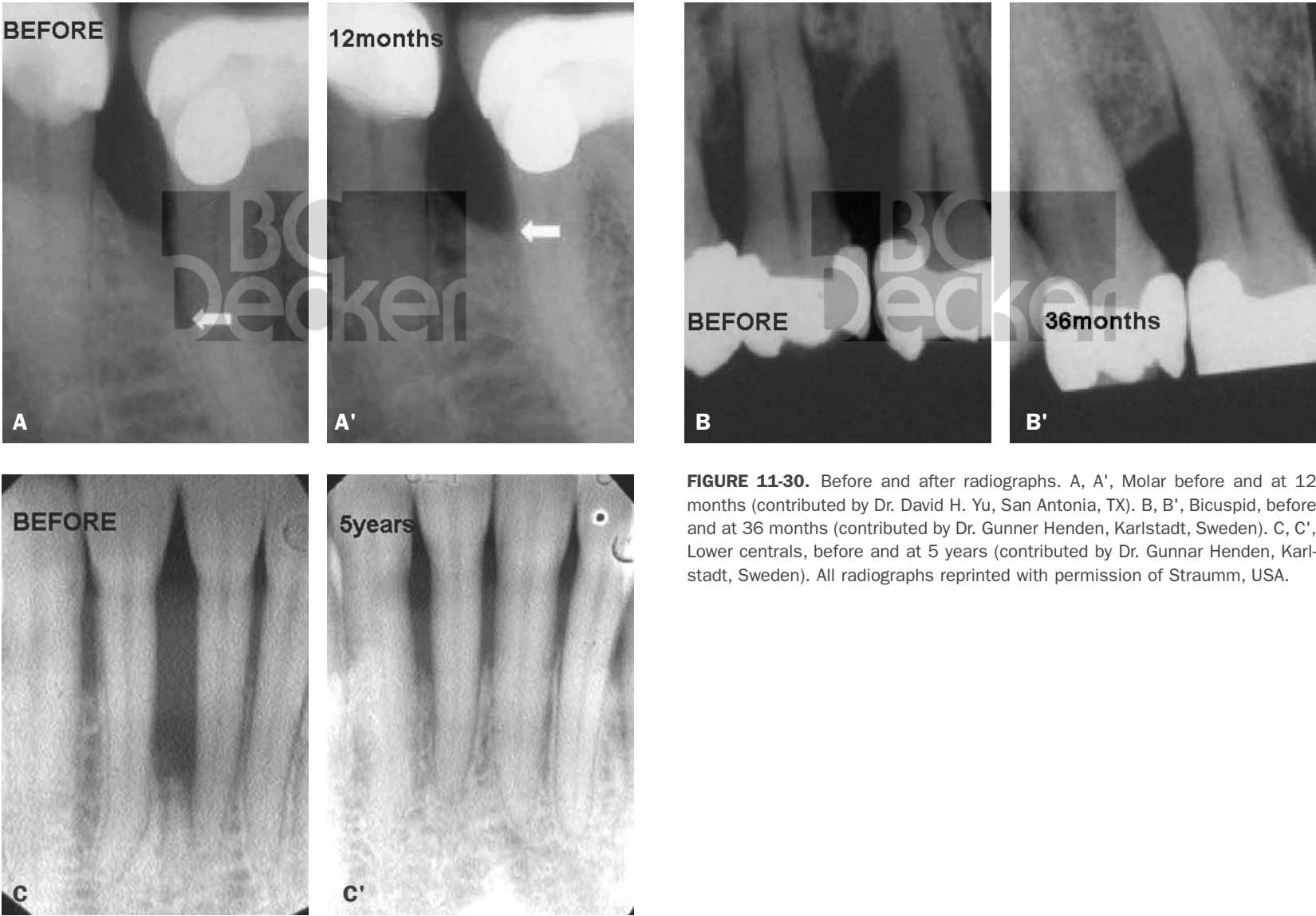


FIGURE 11-30. Before and after radiographs. A, A', Molar before and at 12 months (contributed by Dr. David H. Yu, San Antonio, TX). B, B', Bicuspid, before and at 36 months (contributed by Dr. Gunner Henden, Karlstadt, Sweden). C, C', Lower centrals, before and at 5 years (contributed by Dr. Gunnar Henden, Karlstadt, Sweden). All radiographs reprinted with permission of Straumann, USA.

Table 11-4 Guided Tissue Regeneration Evidence-Based Treatment Decision Tree			
Components	Edentulous Area Approximating Defect	Defect Location	Interproximal
Soft tissue Flap design*	Interproximal space width MPPT	> 2 mm SPPF	≤ 2 mm Crestal Intrabony defect ≥ 4 mm**
Defect anatomy	Wide RDA ≥ 37°	3 Walls Nonsupportive	Narrow RDA ≤ 27° Supportive
Bone	Shallow < 4 mm	Deep > 4 mm	Shallow 4 mm Deep > 4 mm
Membrane Graft***	Titanium e-PTFE Graft + bioabsorbable	Bioabsorbable amelogenins Increasing predictivity	
Adapted from Cortellini and Tonetti (2005) and Cortellini and Bowers (1995). e-PTFE = expanded polytetrafluoroethylene; MPPT = modified papillary preservation technique (Cortellini and colleagues, 1995); RDA = radiograph defect angle; SPPT = simplified papillary preservation flap (Cortellini and colleagues, 1999). *Maximum preservation required for primary closure. **Minimum ideal defect depth. ***Graft: demineralized freeze-dried bone allograft, Bio-Oss, Emdogain.			



Furcations

Multirrooted teeth offer unique and challenging problems for the periodontist. The furcation area, because of the interrelationships between the size and shape of the teeth, the roots and their alveolar housing, and the varied nature and pattern of periodontal destruction, creates situations in which routine periodontal procedures are somewhat limited and special procedures are generally required. Waerhaug (1980) has shown that the best chance for success lies in early recognition and treatment.

Diagnosis

Not counting the third molars, 24 potential furcations exist, and diagnosis is best made through use of radiography and clinical probing. Radiographs are not reliable when used by themselves. Most furcations can be detected clinically by probing with a no. 23 explorer or Nabers no. 1 and 2 curved probes (Figure 12-1).

Diagnosis is made more difficult by certain anatomic factors. The trunk on the lingual aspect of the lower mandibular molar is longer than on the buccal aspect and greater on the second molar than on the first (Figure 12-2, A and B). The maxillary molars pose a special problem in that the mesial furcation, as opposed to the distal furcation, is located in the palatal third on the tooth (Figure 12-2C). The mesial furcation can therefore be approached only from the palate. The distal furcation is higher than the mesial (Figure 12-2D) and is therefore more easily involved.

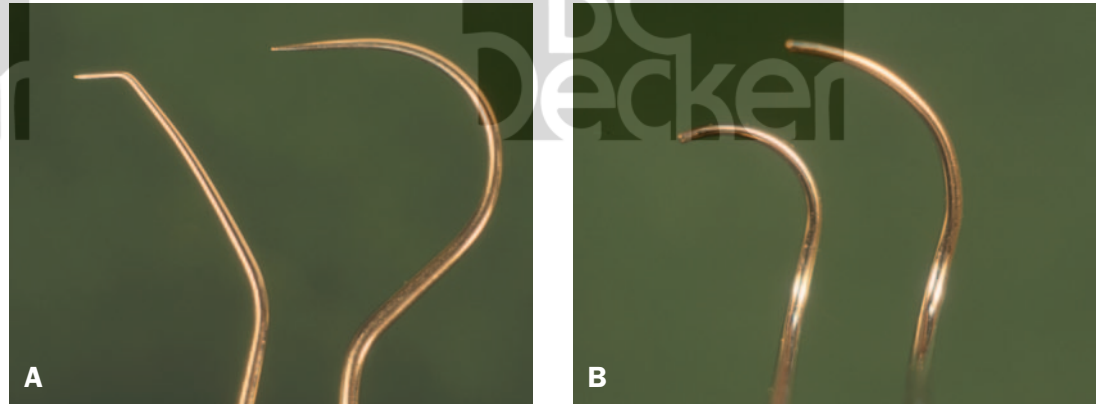


FIGURE 12-1. Instruments used for furcation deflection. A, No. 23 explorer. B, Nabers no. 1 and 2 curved probes.



FIGURE 12-2. Mandibular and maxillary molars. A and B, Buccal and lingual views of a mandibular molar showing that furcation is longer on the lingual than on the buccal aspect. C and D, Mesial and distal views of a maxillary molar showing mesial furcation to be palatal and the mesial root to be broader. Note that the mesial and distal roots are as long as the palatal root.

Furcation Anatomy Terminology

Carnevale and colleagues (2003) noted the following furcation terminology:

Root complex: the portion of the root apical to the cementoenamel junction (CEJ) is divided into two parts: the root trunk and root cone (Figure 12-3)

Root trunk: the undivided portion of the root from the CEJ to the furcation

Root cone: that part of the root that extends below the furcation

Furcation: the area between the root cones

Furcation fornix: the roof of the furcation (see Figure 12-3B)

Furcation entrance: the point of union between the root trunk and cones (see Figure 12-3B).

Degree of separation: the angle of separation between the roots (Figure 12-3C)

Divergence: the distance between two roots (see Figure 12-3C)

Coefficient of separation: the length of the root cones in relation to the root complex (Figure 12-3D)

The ideal tooth for root amputation has the following characteristics:

- 1. Short root trunk
- 2. Divergent roots
- 3. Long, round roots

- 4. Favorable crown-to-root ratio
- 5. Minimal vertical osseous defects

Classification

Newell (1981, 1984), in his reviews of the literature, noted that the classifications by Glickman (1958), Hamp and colleagues (1975), and Lindhe (1983) are the most universally used. These classifications are based on horizontal loss of interradicular bone. To these, Newell added one by Tarnow and Fletcher (1984), which is a subclassification, measuring vertical bone loss from the roof of the furcation.

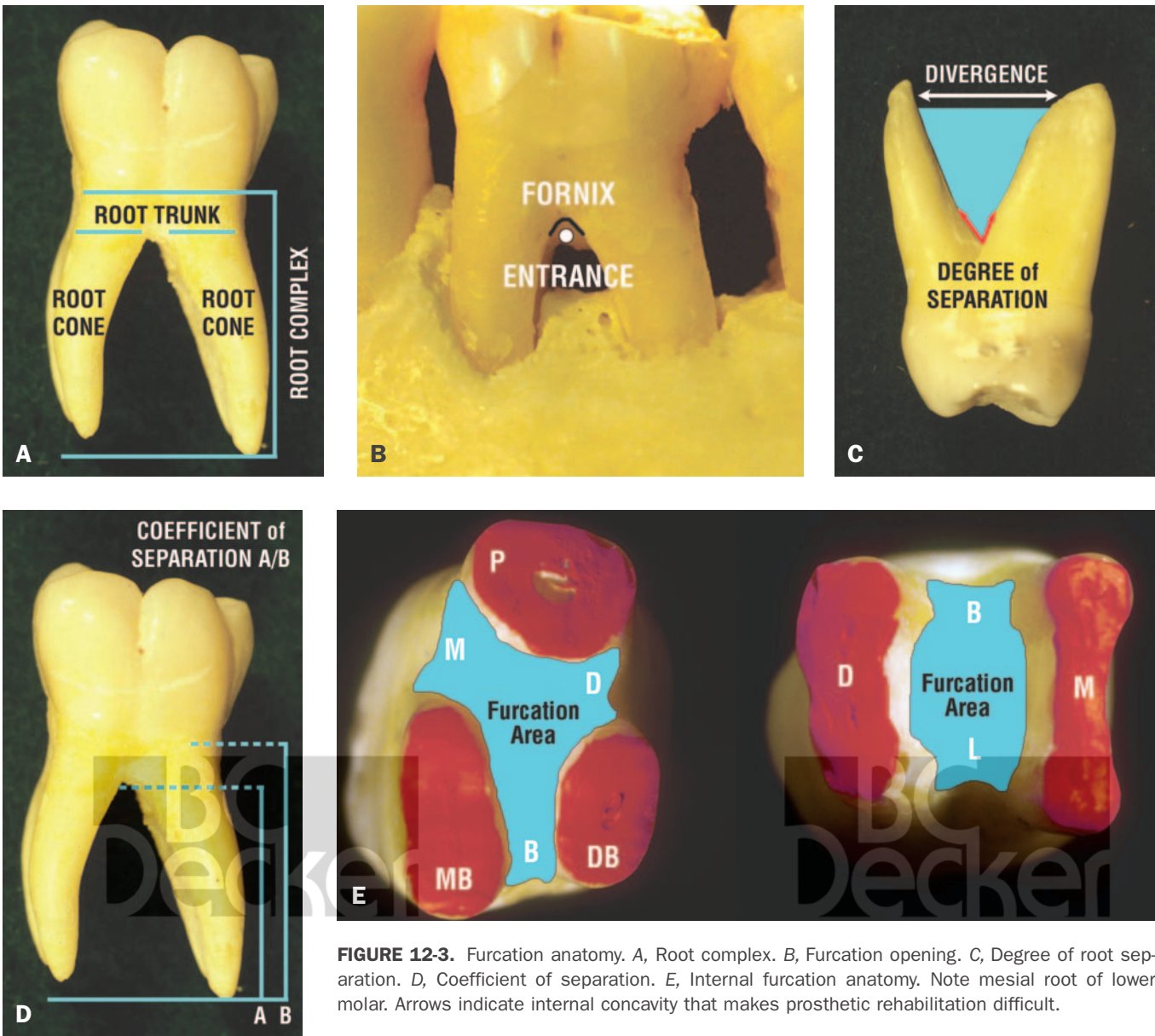


FIGURE 12-3. Furcation anatomy. A, Root complex. B, Furcation opening. C, Degree of root separation. D, Coefficient of separation. E, Internal furcation anatomy. Note mesial root of lower molar. Arrows indicate internal concavity that makes prosthetic rehabilitation difficult.

**Glickman (1958):
Horizontal Classification**

- Grade I: incipient involvement into a flute of furcation with suprabony pockets and no interradicular bone loss (Figure 12-4)
- Grade II: any involvement of the interradicular bone without a through-and-through ability to probe (see Figure 12-4A)
- Grade III: through-and-through loss of interradicular bone (Figure 12-4B)

Grade IV: through-and-through loss of interradicular bone, with total exposure of furcation owing to gingival recession (Figure 12-4C)

**Lindhe (1983):
Horizontal Classification**

- Grade I: loss of interradicular bone less than or equal to one-third (Figure 12-5A) (initial)
- Grade II: loss of interradicular bone greater than one-third but not through and through (Figure 12-5B) (partial)

Grade III: through-and-through loss of interradicular bone (Figure 12-5C) (total)

**Tarnow and Fletcher (1984):
Vertical Classification**

- Grade A: vertical loss of 1 to 3 mm
- Grade B: vertical loss of 4 to 6 mm
- Grade C: vertical loss of 7+ mm

For the purpose of clarity, the Lindhe classification (I, II, III) is used throughout the remainder of the text except where noted.

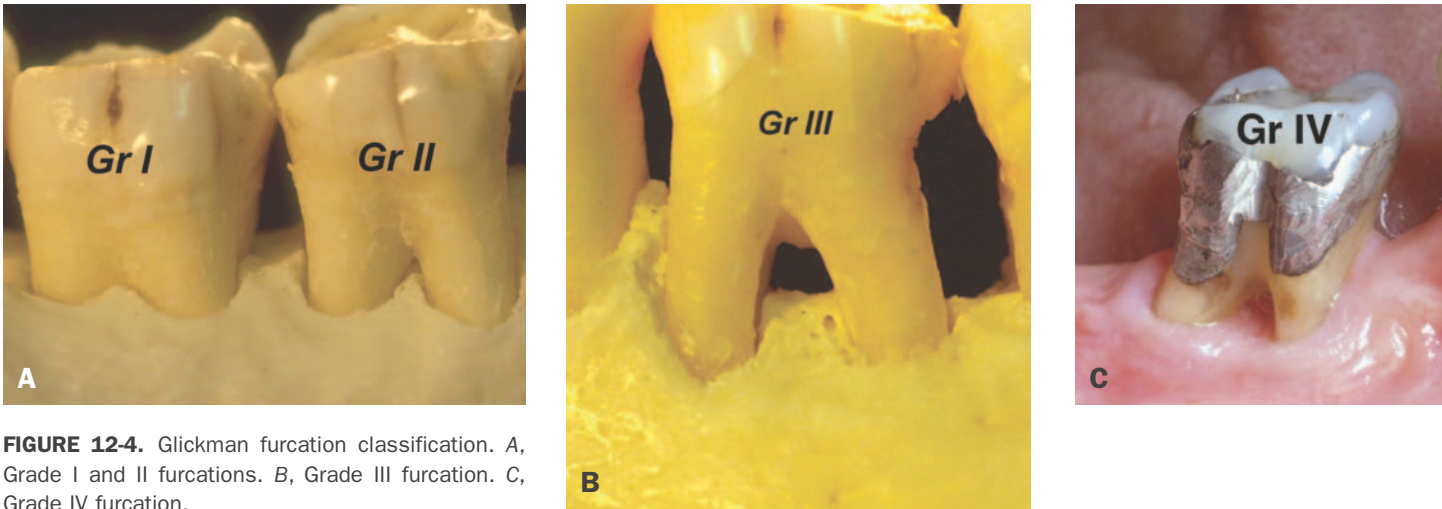


FIGURE 12-4. Glickman furcation classification. A, Grade I and II furcations. B, Grade III furcation. C, Grade IV furcation.



FIGURE 12-5. Lindhe furcation classification. A, Grade I furcation. B, Grade II furcation. C, Grade III furcation.

Treatment

Treatment is generally based on the nature and degree of furcation involvement. It is therefore important to understand which classification is being used in discussing treatment. The major classifications and the generally accepted modalities of treatment are outlined in Table 12-1. These are to be used only as a guide because treatment selection varies according to the following considerations:

- 1. Size, shape, and divergence of roots
- 2. Size of the crown
- 3. Length of the root trunk (distance between the CEJ and the furcation area)
- 4. Crown-to-root ratio
- 5. Amount of remaining bone support

Scaling and Curettage, Gingivectomy, Odontoplasty

These procedures are used for incipient lesions in which no interradicular bone involvement exists (grade I, Glickman) and the pockets are suprabony. Treatment is therefore limited to pocket reduction, gingivectomy, and possibly reshaping of tooth structure, odontoplasty (Goldman, 1958), to widen the narrow furca entrance.

Furcation Plasty—Odontoplasty and Osteoplasty

Hamp and colleagues (1975) described furcation plasty as raising a mucoperiosteal flap to provide access to the furcation area and combining scaling and root planing, osteoplasty, and odontoplasty to remove local irritants and open the furcation to allow the patient access to clean and maintain the area. The result should be a firm, well-contoured papilla to cover the interdicular space. This procedure is recommended for grade I and early grade II lesions (Figures 12-6 and 12-7).

Odontoplasty should be used judiciously because it can result in hypersensitivity and pos-

sible pulpal involvement. Osteoplasty and ostectomy should also be performed cautiously to minimize the risk of further loss of attachment.

Grafting

The furcation area is characterized by defects, the walls of which are primarily of tooth structure. Therefore, although the area is capable of holding a graft, it has little or no vascularity to support one. For this reason, the success of grafts is limited in furcations (Sepe and colleagues, 1978; Saunders and colleagues, 1983). Grafts are indicated where destruction of the furcation is only partial (grade I or II) or where deep vertical lesions have still left some bone on the inner aspect of the roots (Bowers and colleagues, 2003). See Chapter 11, “Guided Tissue Regeneration,” for further details.

Tunnel Preparation

Tunnel preparation is the surgical exposure of the furcation, which is indicated for advanced grade II and III lesions in which resection is not possible (Figure 12-8). It requires roots that are long and divergent and is generally indicated for the mandibular molars. It often fails because of decay in the furcation area (Lindhe, 1983).

Hellden and colleagues (1989) recently studied the long-term prognosis of tunnel preparations on 149 teeth with a range of 10 to 107 months (the mean prognosis was 37.5 months). They showed that 75% were still caries free, 6.7% (10 teeth) were extracted, 4% (7 teeth) were hemisected, and 15.4% (23 teeth) showed initial or established caries. They concluded that teeth with tunnel preparations have a considerably better prognosis than that previously reported (see Figures 12-4C and 12-5).

Root Resection

This procedure involves removing one or more roots from a multirooted tooth. Proper tooth

selection is important for success. The ideal tooth is one with well-developed long roots that have adequate divergence and a narrow root trunk. The furcation area should have a good deal of remaining bone, and the remaining roots should have adequate support and a favorable crown-to-root ratio (Figure 12-9).

Root resection is a highly predictable procedure with a success rate of 96.7% (701 molars), similar to that of implants (97%; 1,472 implants) (Fugazzatto, 2001) and greater than the 65 to 74% of implants placed into poor-quality bone (Engquist and colleague; 1991; Jaffin and Berman, 1991). Carnivale (1990) had only a 3.6% rate of tooth loss (19 of 488 teeth) after 5 years, which was similar to Ricchetti’s (2004) 9.6% after 11.5 years (19 of 169 teeth). Langer (1981) had a 38% rate of loss (38 of 100 teeth). This high number has been attributed to prosthetic post and core fracture (see Contraindications).



FIGURE 12-6. Furcation plasty of grade I furcation (Lindhe) A, Prior to treatment. B, Osteoplasty and ostectomy completed. C, Clinical representation of completed case. Note contour of tissue in furcation.

Table 12-1 Classification and Treatment of Furcation				
Glickman (1958)		I	II	III or IV
Lindhe (1983)		I	II	III
Tarnow (1984)		A, B, or C	A, B, or C	A, B, or C
Treatment	Scaling and root planing Gingivectomy Odontoplasty	Odontoplasty* Osteoplasty*†	Odontoplasty* Osteoplasty*† Grafting ¹ GTR ¹ Flap and Ca Tunnel preparation Root resection	Root resection Tunnel preparation GTR ²

*When done together, termed furcation plasty.

†Osteoplasty is used here to mean both osteoplasty and ostectomy.

¹High predictability.

²Low predictability.

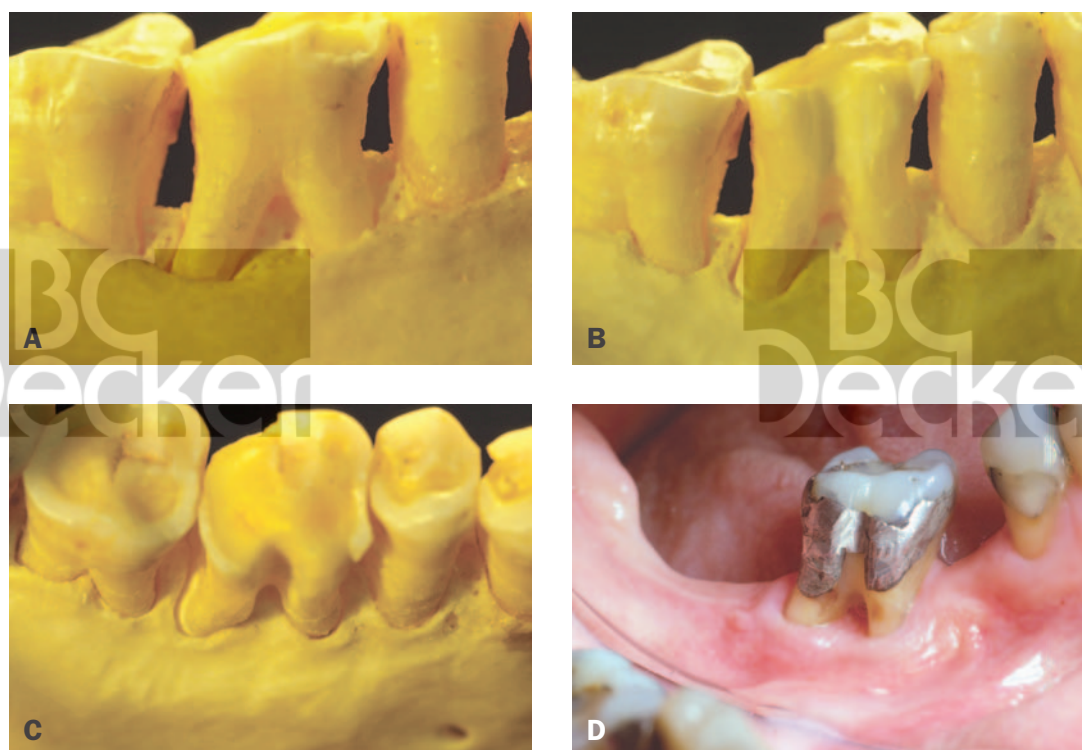


FIGURE 12-7. Furcation plasty of grade II furcation. A, Before treatment. B, Osteoplasty and odontoplasty completed. C, Occlusal view showing the extent of osteoplasty. D, Clinical representation of healed furcation plasty.



FIGURE 12-8. Tunnel preparation. A, Grade III furcation prior to correction. B, Tunnel preparation completed. C, Small interdental brush is inserted into and through the furcation to show that the inner portion of the furcation can be cleaned.

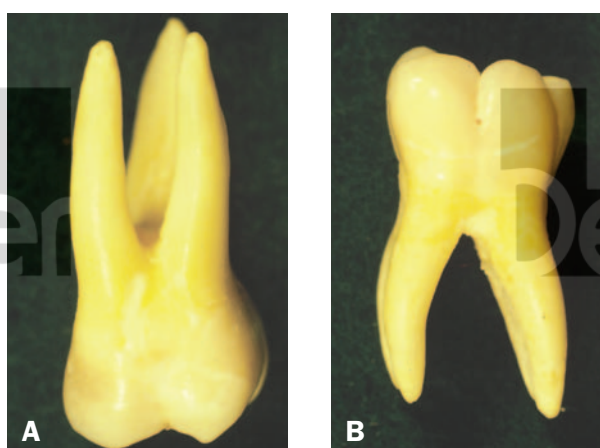


FIGURE 12-9. Root resection—proper tooth selection. A and B, Maxillary and mandibular teeth showing adequate root length and divergence with a narrow trunk and excellent crown-to-root ratio.

Clinical Terminology

The two basic types of sectioning are *tooth sectioning*, which is defined as the division of the tooth into its individual roots, and *root resection*, which is the removal of part of the tooth. Mandibular molars are usually treated by *hemi-section* (also termed *bicuspidization* or *separation* with or without root removal, whereas maxillary molars are generally treated by *root amputation*.

Both procedures may be carried out as *vital* (Haskill and Stanley, 1982) or *nonvital* procedures. If vital sectioning is employed, provisions for final endodontic therapy should be made.

All tooth-sectioning procedures require the use of buccal and lingual (palatal) flaps for access and visibility for sectioning and osseous surgery. *Osseous surgery should also be performed at the time of sectioning.*

Prognosis

A number of studies (Hamp and colleagues, 1975, 1992; Langer and colleagues, 1981; Carnevale and colleagues, 1991; Suärdfström, 2001) have reviewed the long-term prognosis (5–10 years) of resected

molars. The studies demonstrate that with proper tooth selection, treatment, and restoration, a success rate of between 85 and 100% is achievable.

Note: This compares more favorably than shorter implants placed into type III or IV bone in the posterior maxilla.

It also eliminates the need for multiple surgical procedures, sinus augmentation procedures, and long delays in treatment.

Indications

The following situations can be solved only by removal of one or more roots or extraction of the tooth. Extraction is not always desirable, especially if the tooth is a terminal abutment:

- 1. Grade III lesions
- 2. Deep grade II—mesial or distal furcations or maxillary molars
- 3. Inability to maintain furcations
- 4. Advanced decay
- 5. Severe gingival recession on a single root
- 6. Close root proximity with minimal interseptal bone (commonly seen between the max-

illary first and second molars), preventing adequate embrasure space, as in the case of prosthetic restoration

- 7. Endodontic failure
- 8. Inability to perform endodontic therapy
- 9. Tooth fracture
- 10. Extensive root caries
- 11. Root resorption
- 12. Root perforation
- 13. Severe vertical bone loss about one or more roots
- 14. Inability to achieve predictable regeneration (see guided tissue regeneration [GTR] defect selection)

Contraindications

Success, like failure, is based generally on tooth selection, and for this reason, preoperative evaluation is critical (Figure 12-10):

- 1. Teeth with a poor crown-to-root ratio on the remaining roots
- 2. Inadequate bone support on roots to be retained
- 3. Unfavorable root anatomy of retained teeth

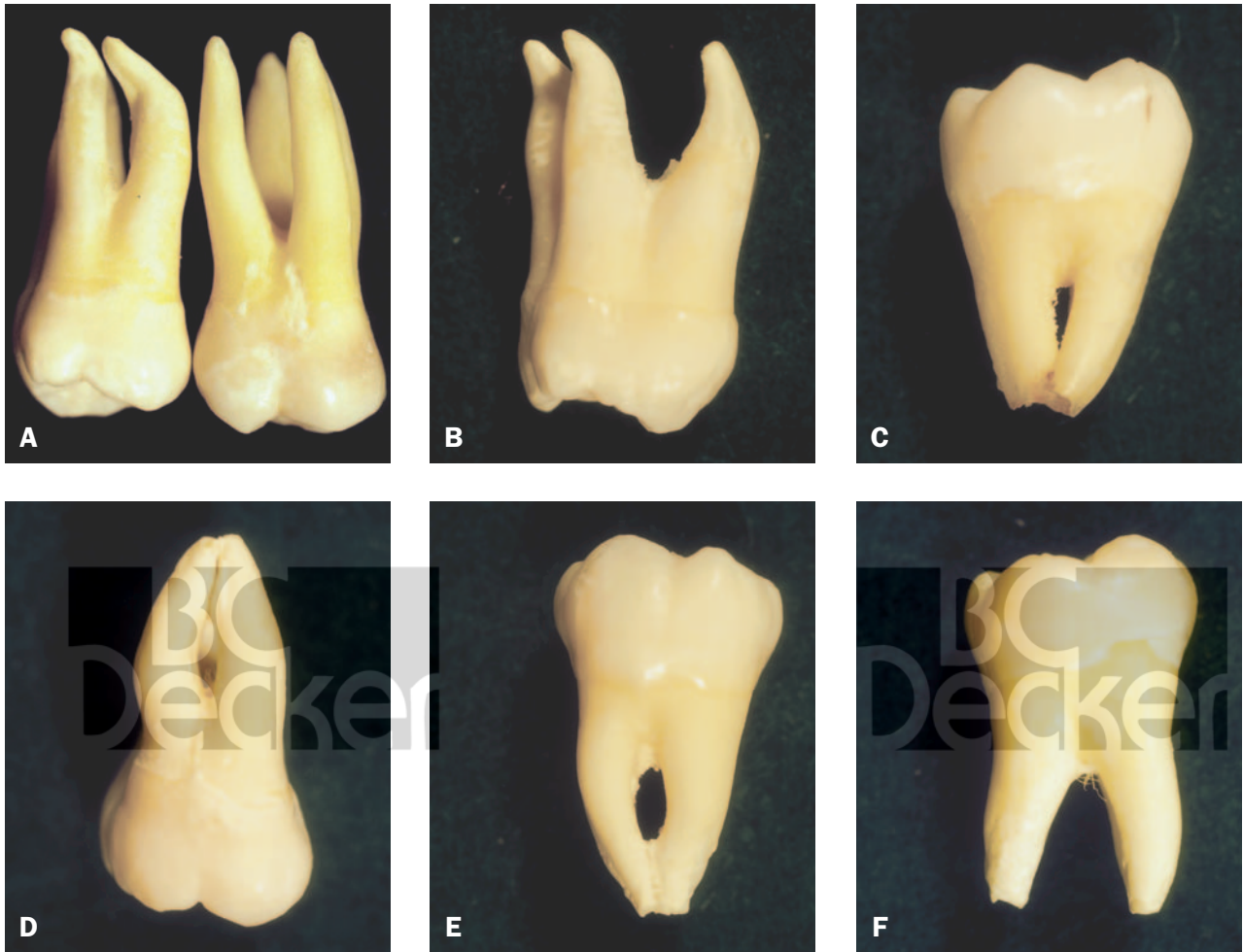


FIGURE 12-10. Contraindications for root resection. A, Maxillary molar A with an ideal crown-to-root relationship. Molar B has too long a root trunk and curved roots. B, Root trunk is too long. C, Unfavorable crown-to-root ratio. Bell-shaped crown. D, Fused maxillary buccal roots. E, Fused mandibular roots. F, Roots are too short.

4. Long tooth trunks
5. Fused roots
6. Extensive webbing between roots
7. Bell-shaped crowns
8. Teeth in which endodontic treatment and restoration are not possible on the remaining roots
9. Poor surgical access
10. Inability to perform oral hygiene procedures
11. Poor form of remaining roots
12. Splinting is not possible
13. Severe vertical bone loss internally
14. Excessive endodontic fills ($\geq 30\%$)
15. Inadequate tooth structure for establishment of biologic width
16. Excessive mobility
17. Inadequate tooth position
18. Prosthetics
 - a. Long prosthetic spans
 - b. Inadequate root width (< 3 mm)
 - c. Post and core size requirements

Considerations

In considering which roots to remove, certain anatomic factors should be taken into consideration. The mesiobuccal root of the maxillary first and second molars, although larger than the distal root, tends to have a deep concavity. This cavity makes prosthetic preparation and maintenance difficult and may result in perforation and root fracture (Bassada, 1969; Langer and colleagues, 1981). This is not true of the distal root, which is round or ovoid (Figure 12-11).

The maxillary first molar has a shorter root trunk than the second molar, and the mesial furcation is shorter and more palatal than the distal.

Note: Owing to the close root proximity of the distobuccal (DB) root of the first molar and the mesiobuccal (MB) root of the second molar, the DB root is most often removed because of breakdown in this area.

When both the mesial and distal furcations are involved, a palatal root amputation should be considered if the buccal furcation is intact. This is because the palatal root has an unfavorable axial inclination and an unfavorable prosthetic relationship with the first bicuspid.

The mesial root of the mandibular molars, although larger, has two canals and a deeper concavity, in contrast to the distal root, which has one canal and is ovoid. The distal root is easier to prepare prosthetically and involves a lesser chance of endodontic failure. Use of the distal root requires a bridge; this is not the case when using the mesial root (Figure 12-12).

Note: Gher and Dunlap (1980) and Herman and colleagues (1983) noted that teeth with long root trunks and short roots may have already lost a significant amount of support.

Diagnostic Factors for Determining Which Root to Remove (Corranza and colleagues, 2002)

1. Eliminates the furcation
2. Provides postsurgical maintainable architecture
3. Has the greatest attachment loss
4. Best eliminates the periodontal problems
5. Has the greatest number of anatomic problems
 - a. Curvature
 - b. Grooves
 - c. Root flattening
 - d. Accessory and multiple root canals
6. Least complicates future periodontal maintenance

Mandibular Molar Furcations: Hemisection Procedure

With the patient under anesthesia, probing for the nature and extent of the furcation involvement and the outline of the surrounding osseous topography is completed prior to surgery. A mucoperiosteal flap is elevated buccolingually.

It is often convenient to draw a straight line in pencil on the tooth from both the buccal and lingual furcations to the occlusal surface, where they are joined. The line is drawn with the same axial inclination as the tooth. This gives the clinician a perspective on sectioning the tooth, especially if the molar is tilted.

Using a friction-grip no. 701L enamel shaver or tapered no. 700 bur, the tooth is sectioned in a

buccolingual direction. The initial cuts are made by starting at the furcation entrance and drawing the bur outward and upward along the pencil lines.

The sectioning is continued until the buccal and lingual grooves are joined together. A thin piece of the pulpal floor is still intact in the furcation area.

Note: High-speed burs should be used with extreme care on the thin pulpal floor for fear of damaging the remaining furcal bone.

A no. 4 rounded bur in a slow handpiece, may also be used to perforate the roof of the furcation. A small chisel can then be placed in this area for final separation.

If one of the roots is to be removed, that is done, and the final tooth contouring in the furcation area is completed. Attention must be paid to removing any residual spurs of pulpal floor left attached to the root or undercuts and checking for and removing any residual internal furcations. *Without this final contouring, failure may result.*

Osseous surgery is completed by removing the residual internal osseous crater on the mesial or distal aspect of the remaining root. The broad residual ridge is now thinned buccolingually to facilitate pontic placement and plaque control. The distal root in general has a lower mesial bone level than the distal aspect of the approximating premolar or cuspid. This will often necessitate a leveling of the ridge. Some marginal bone may have to be removed for the final positive bony architecture.

The procedure is shown clinically in Figures 12-13 to 12-15. If both roots are periodontally sound once hemisected, they can be separated orthodontally and used individually or splinted together (Figure 12-16).

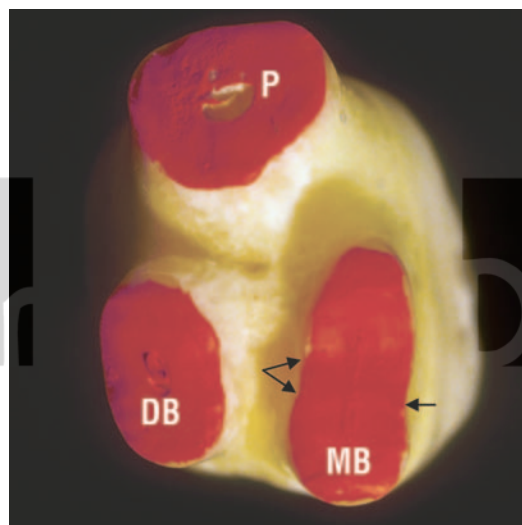


FIGURE 12-11. Cross section of a maxillary molar. Arrows indicate concavities usually found on the mesial root, which make restoration more difficult.



FIGURE 12-12. Cross section of a mandibular molar. Arrows point to concavity on the mesial root, which makes prosthetic treatment difficult.



FIGURE 12-13. Mandibular hemisection. *A* and *B*, Buccal and lingual views prior to treatment. *C*, Temporary crowns removed. *D*, *E*, Periodontal probes positioned to show deep grade II furcations. *F*, Occlusal view of teeth sectioned. *G*, X-ray verification for complete hemisection. Note the small bridge of tooth structure still remaining on the second molar. *H*, Mesial roots removed, teeth prepared, internal furcation contoured, osseous surgery completed, and flaps apically positioned. *I*, Temporization. *J*, Five years later; case complete. *K*, Final x-ray study 5 years later.

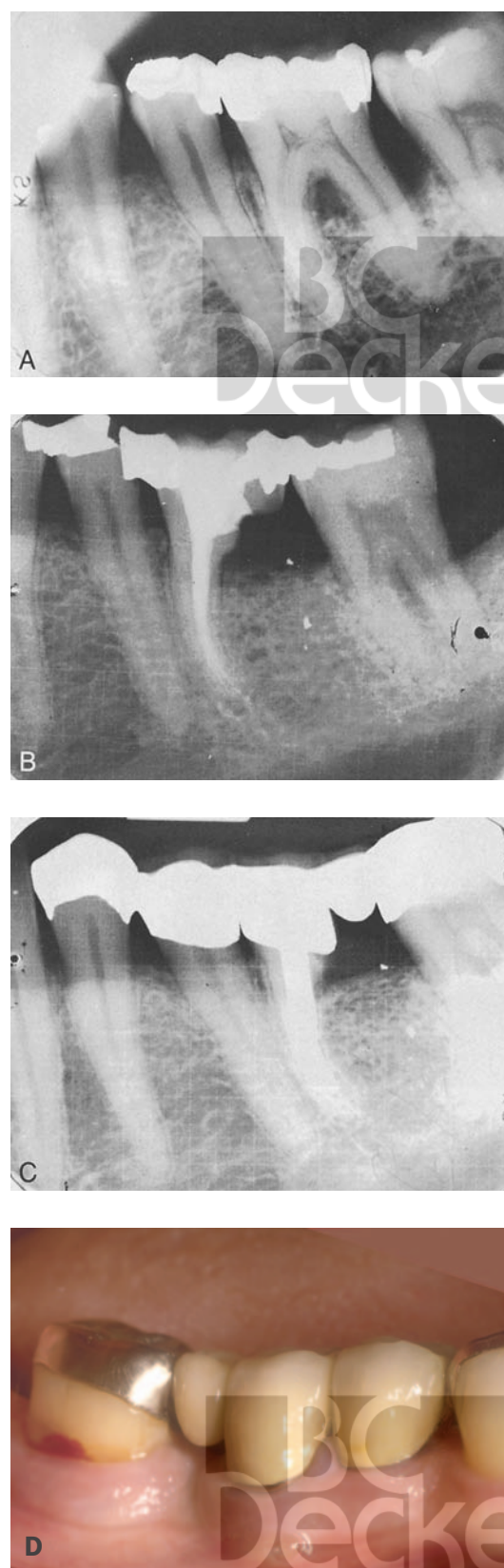


FIGURE 12-14. Mandibular hemisection. A, Pretreatment x-ray study showing severe involvement of the distal root. B, Hemisection completed. C and D, Six years later, the restoration is complete and bone has filled in about the remaining root. Prosthetics courtesy of Dr. William Irving, Needham, MA.

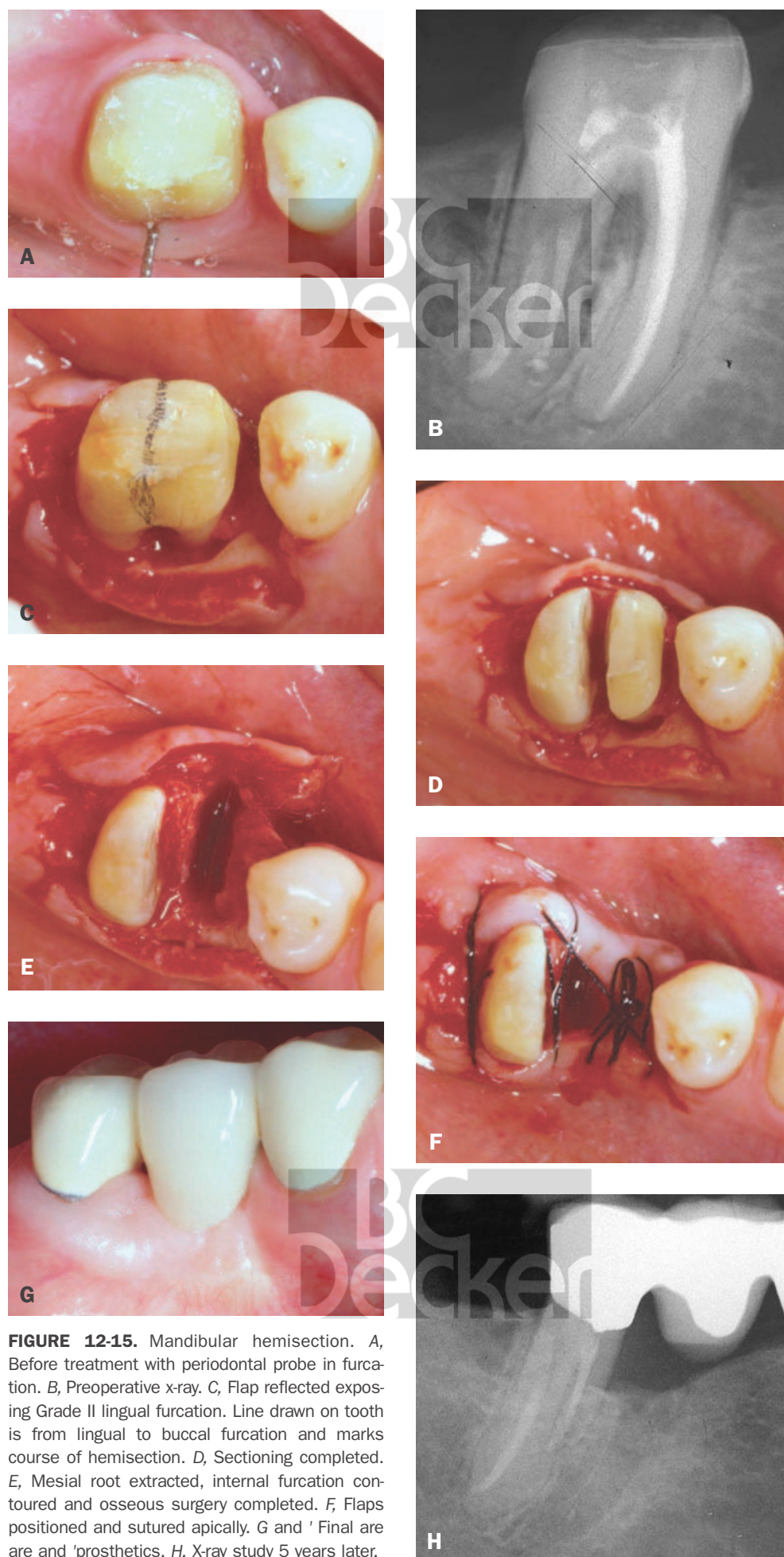


FIGURE 12-15. Mandibular hemisection. A, Before treatment with periodontal probe in furcation. B, Preoperative x-ray. C, Flap reflected exposing Grade II lingual furcation. Line drawn on tooth is from lingual to buccal furcation and marks course of hemisection. D, Sectioning completed. E, Mesial root extracted, internal furcation contoured and osseous surgery completed. F, Flaps positioned and sutured apically. G and H, Final are and 'prosthetics. H, X-ray study 5 years later.

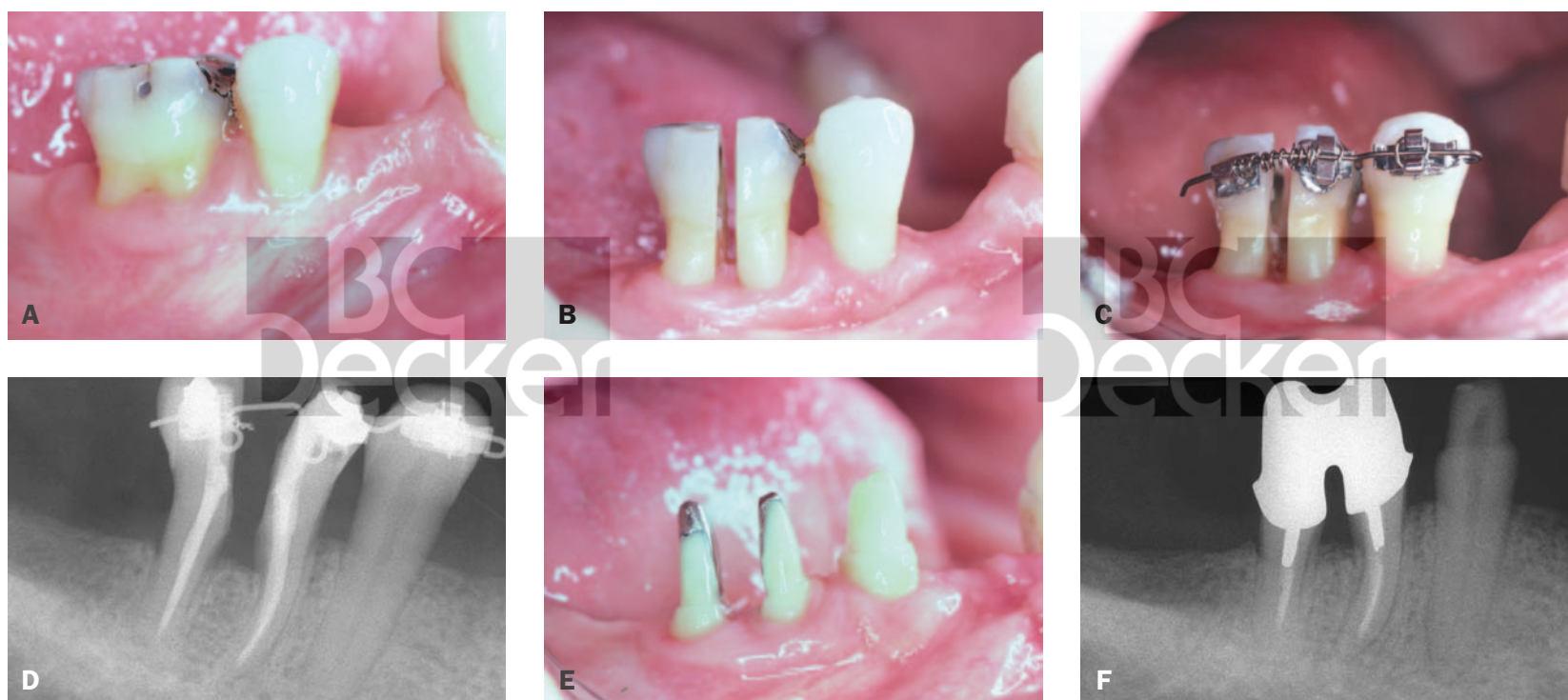


FIGURE 12-16. Hemisection and bicuspidization. A, Before treatment. B, Hemisection of roots. C, Orthodontic separation of roots for creation of an adequate embrasure space. D, X-ray study showing final separation. E, Individual roots prepared for crowns. F, X-ray study showing final casting in place. Courtesy of Cary Golavic, Portsmouth, NH.

Maxillary Furcations: Root Amputation Procedure

The maxillary molars and bicuspid are most often treated by root amputation and root resection, respectively. Tooth sectioning is generally used only in advanced periodontal and prosthetic cases.

Majzoub and Kon (1992) recently showed that in 86% of the distobuccal root resections in maxillary first molars, there was insufficient biologic width (< 2.04 mm) remaining after tooth preparation.

In Figure 12-17, A and A' the maxillary molar has severe bone loss about the mesiobuccal root that requires root amputation. A microperiosteal flap is elevated buccally and palatally prior to starting.

The first step involved the use of a no. 4 or no. 6 round bur for removal of the bone overlying the affected root. This will facilitate the horizontal sectioning of the root below the fornix of the furcation, thus avoiding damage to the adjacent tooth structures (Figure 12-17, B and B').

In Figure 12-17, C and 12-17C', a no. 7016 friction-grip enamel shaver or tapered diamond bur is used to section the root with a perpendicular or oblique cut, which is begun below the most coronal level of the furcation. The sectioning is completed in stages each time a curved explorer is used to check for total separation. To

prevent damage to adjacent roots, toothpicks or orthodontic wire is sometimes inserted into the open furcations to act as a stop or guide.

An oblique cut is now made near the CEJ and angled into the initial cut (Figure 12-17, D and D'). This will facilitate the removal of the root tip and increase access to and visibility of the internal furcation.

The root is gently elevated with a small elevator (Figure 12-17, E and E'). Using the same bur, the remaining tooth structure in the furcation is smoothed to prevent any overhangs, and the coronal portion of the tooth is blended in (Figure 12-17, F and F').

Under direct visualization, the final osseous contouring is determined. Rosenberg (1988) recommended the following osseous management after a root amputation or trisection procedure:

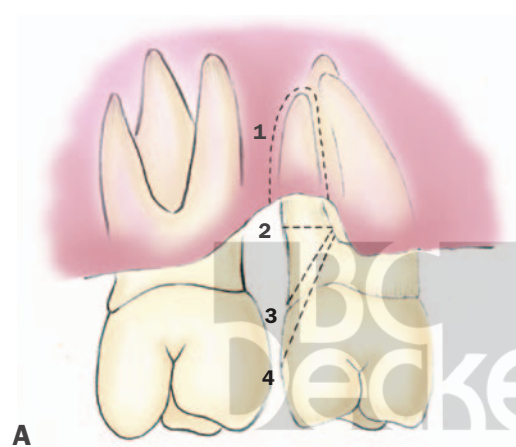
1. Elimination of the residual bony ledge that extends into the exposed furcation to the facial plate at the root extraction (Figure 12-17F')
2. Removal of part of the facial plate in the extraction site to form a vertical groove (see Figure 12-17F and 12-F')
3. Reduction of the facial lingual width of the interdental septum in the area of the extraction
4. Removal of any residual craters on the internal aspects of the remaining roots

5. Odontoplasty for elimination of internal furcations (see Figure 12-17F and 12-17G)
6. Osteoplasty and ostectomy for establishing final positive physiologic form with adjacent teeth

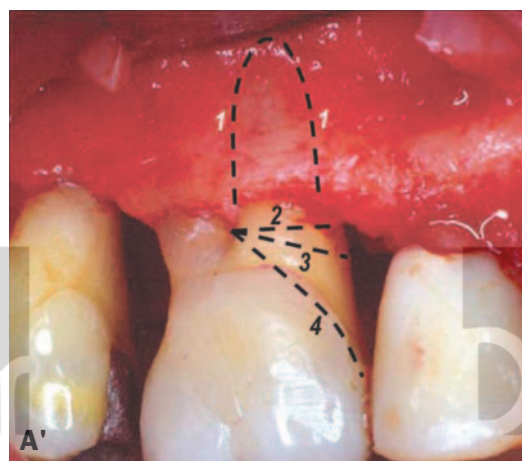
The final contour will allow a normal parabolic gingival form and will be open enough to permit adequate plaque control procedures (Figure 12-17, H and H'). The procedure is outlined clinically in Figures 12-18 to 12-22.

Common Reasons for Failure

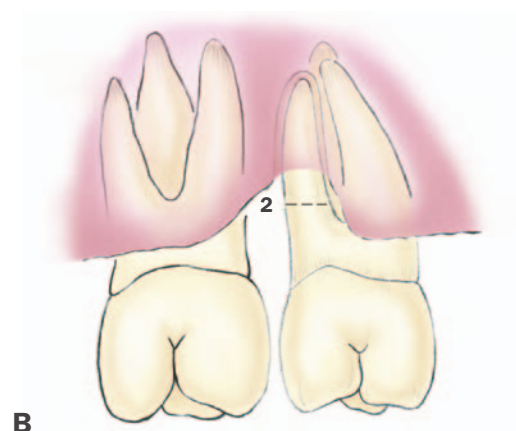
1. Root fracture because of
 - a. Lack of conservative endodontic treatment—overinstrumentation
 - b. Failure to restore teeth adequately with posts and crowns
 - c. Inadequate provisional or final splinting for stabilization
2. Poor tooth selection
3. Incomplete sectioning
4. Failure to diagnose involvement of other furcations
5. Failure to correct osseous deformities, resulting in residual pockets
6. Failure to remove residual furcations
7. Inability to maintain an adequate level of oral physiotherapy about adjacent furcations



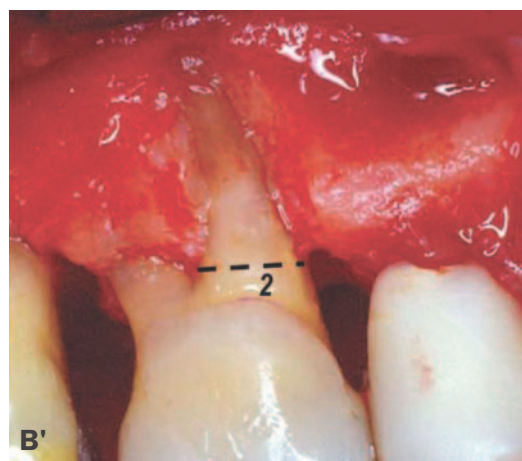
A



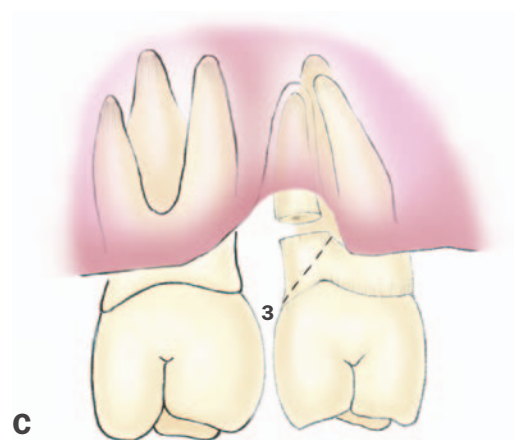
A'



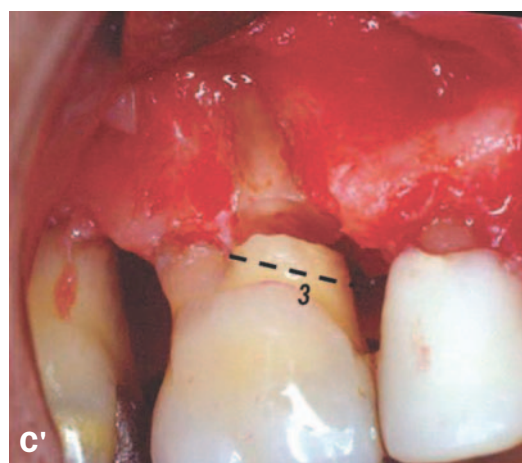
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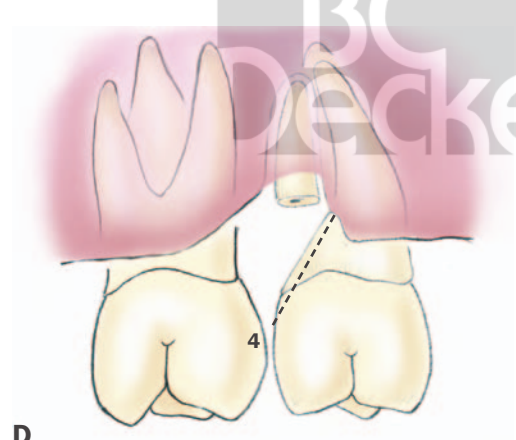
B'



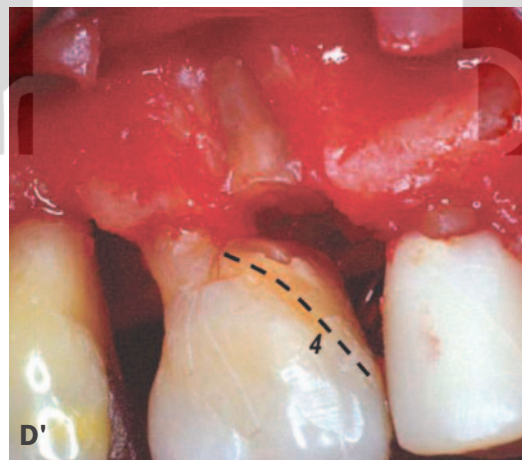
C



C'



D



D'

FIGURE 12-17. Maxillary root amputation—sequence of treatment. A and A', Before resection, with tooth cuts outlined. A round bur is used for bone removal over the affected root. B and B', A 701L bur is used for the second cut. C and C', A flame-shaped enamel finishing bur is used for the oblique horizontal third cut. D and D', Oblique cut completed and final internal contouring established with round and oval enamel finishing burs.

FIGURE 12-17. (continued) *E* and *E'*, Root tip removed. *F* and *F'*, Final root contours established and osseous surgery is completed with a no. 6 round bur and hand instrumentation. *G* and *G'*, Final osseous surgery completed and flaps sutured. *H* and *H'*, Case completed with final prosthetics. Note attention given to internal tooth form.

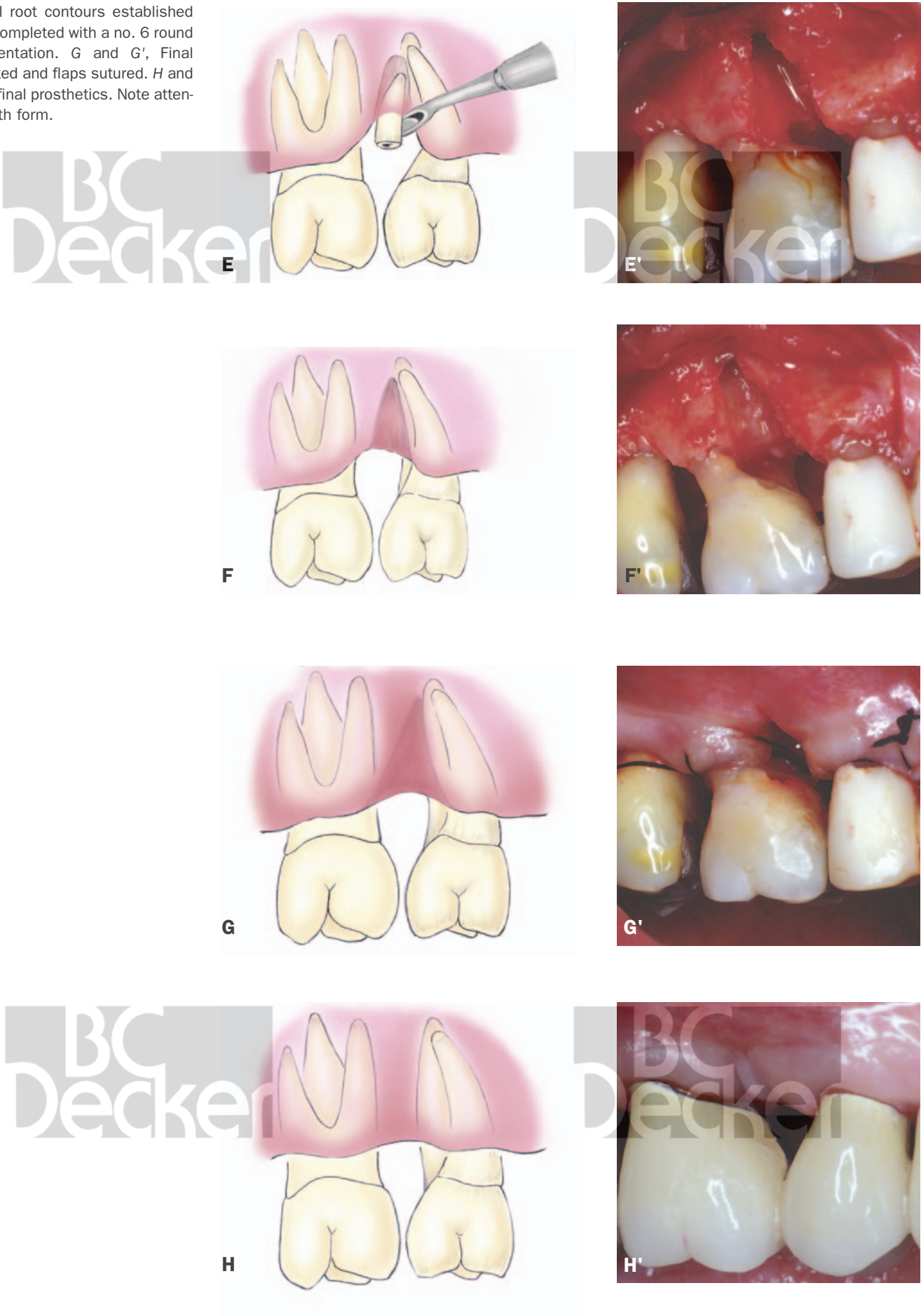




FIGURE 12-18. A, B, Before, distobuccal root to be moved. C, Surgical sequence outlined. D, Round bur (#6) for root exposure. E, 701L bur for horizontal separation of root. F, Distobuccal root removed (#2). G, Residual root is reduced to permit extraction of root-tip. H, Residual root is reduced (#3). I, Root-tip removed and final contouring begun. J, Final contouring of internal furcation (#4). K, Final case, note smooth contour of internal furcation. L, Before for comparison.



FIGURE 12-19. Maxillary root amputation—mesiobuccal root. *A* and *B*, Occlusal and buccal views of crown preparation of a maxillary first molar. *C*, Palatal view displaying deep grade II mesial furcation. *D*, Buccal view of initial mesiobuccal root sectioning beginning at or near the most coronal portion of furcation. *E*, Occlusal view shows the joining of the mesial and distal cuts. *F*, Mesiobuccal root removed and internal furcation prepared. *G*, Buccal plate removed over the extracted root, final osseous contours established, and internal portion of furcation completely prepared. *H*, Occlusal view shows bicuspid contour established. *I*, Flaps apically positioned and sutured. *J*, Initial healing. *K*, Temporization. *L*, Case completed 1 year later. Note total opening of the embrasure for patient access and that the crown was not overcontoured. Prosthetics courtesy of John Dolbec, Easton, MA.



FIGURE 12-20. Palatal root amputation. *A*, Before treatment. *B*, Toothpicks placed in mesial and distal furcations serve as reference points and protect surrounding tissue from damage. *C*, Tooth has been sectioned mesiodistally. The appearance of the toothpicks means that sectioning is complete. *D*, Palatal root has been removed. *E* and *F*, Palatal and buccal views of teeth prepared for prosthetic treatment. Note that the resected molar is treated as a bicuspid. *G*, Occlusal view of the crown with prominent contours that mirror the tooth. *H*, Palatal view of the final prosthetic restoration. Prosthetics courtesy of Dr. Bernard Croll, New York, NY.

FIGURE 12-21. Maxillary distobuccal and palatal root amputation. *A*, Pretreatment x-ray study showing severe bone loss on the distal and palatal roots. *B*, Five-year post-treatment x-ray study. Note total bone regeneration. *C* and *D*, Buccal and palatal views of completed restoration 5 years later. Note excellent contours and embrasures. Prosthetics courtesy of Dr. William Irving, Needham, MA.

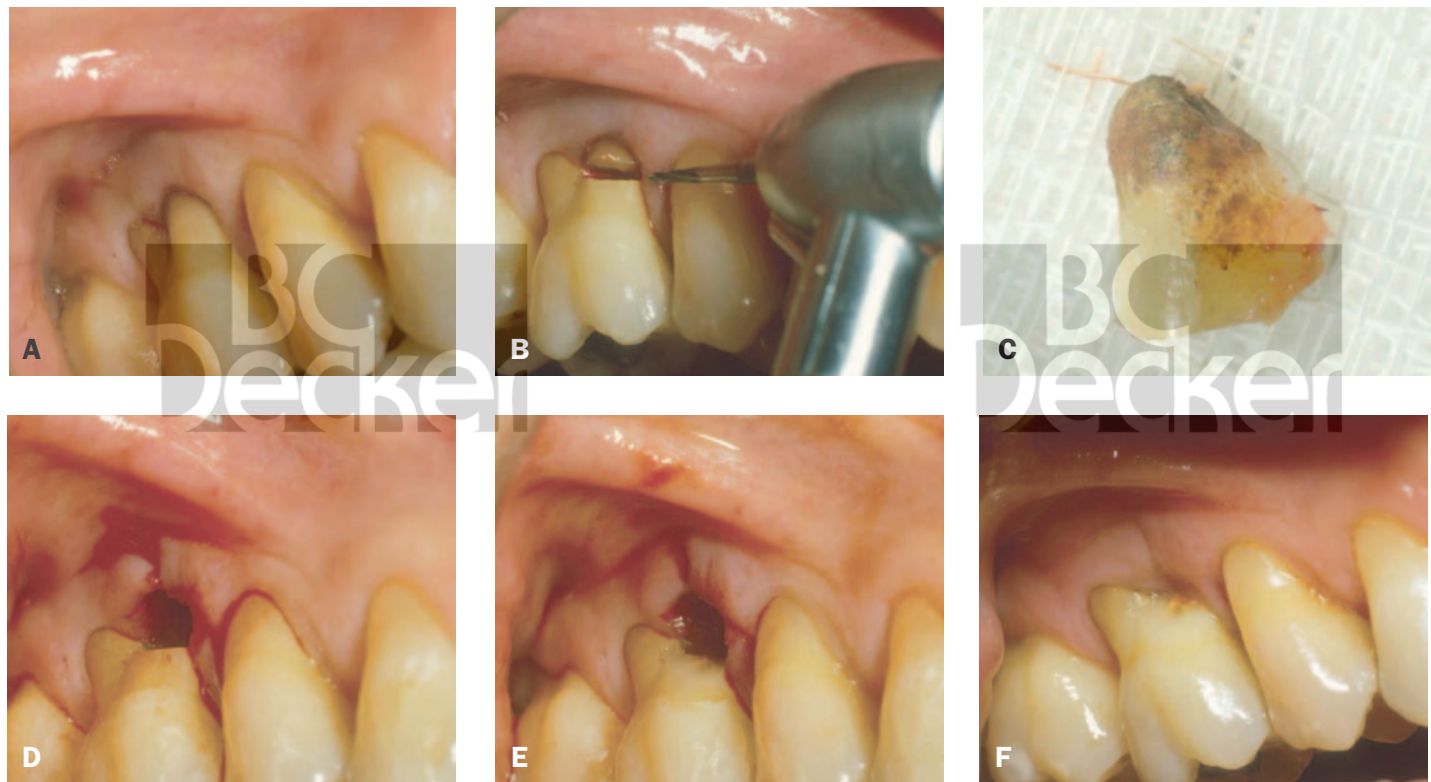


FIGURE 12-22. Mesio Buccal root amputation. A, Before treatment. B, Root sectioned using a 701L bur. C, Root tip removed. D, Root tip with calculus. E, Tooth contoured. Mesial area beveled in. F, Four months later.

Peridental-Endodontal Problems

Patients often have a large radiolucent furcation area, which, to all appearances, presents as a periodontal problem. The tooth should be checked for possible endodontic involvement, and the rest of the mouth should also be examined to see if the finding is consistent with the patient’s overall periodontal situation.

If this is a solitary lesion or the tooth has a large or recent restoration, an endodontic problem should be considered even if the tooth tests vital. Many accessory canals exist in the furcation area (some investigators report up to a 76% incidence), which are open to secondary pulp involvement as periodontal inflammation moves apically. Generally, in cases of primary pulp disease, endodontic therapy will resolve the problem (Figure 12-23).

Endodontic lesions are dissecting in character, and the nature of the root surface and periodontal attachment apparatus remains healthy, permitting complete regeneration or restoration of a healthy periodontal complex after resolution

of the periodontal lesion. Therefore, periodontal therapy is contraindicated prior to endodontic therapy. If periodontal therapy is attempted first, regeneration via endodontic therapy will be limited if it occurs at all. Differential diagnosis is therefore important.

Note: The use of a thin gutta-percha point to probe a fistula is often helpful in determining the origin of the infection.

The differential diagnosis of periodontal and pulp disease is shown in Table 12-2.

Table 12-2 Differential Diagnosis of Periodontal and Pulpal Disease		
Clinical	Pulpal	Periodontal
Age	Any	Older
Pain		
Presence	Yes	Sometimes
Quality	Sharp	Dull
Location	Localized	Diffuse
Thermal sensitivity	Yes	No
Sensitivity to percussion	Yes (intense)	Sometimes (dull)
Pulp vitality	No	Yes
Tooth mobility	No	Yes
Pocketing	No	Deep pockets about tooth
Testula	Submarginal	Fistula leads to periodontal pocket
Probability		
Furcation	No	Yes
Radiolucency	No	Yes
Radiographic		
Interproximal bone loss	No	Yes
Furcation area	Yes	Yes
Apical radiolucency	Yes	No



FIGURE 12-23. Periodontal-endodontic interrelationships. A, A', Before treatment, showing total furcation bone loss and a large apical radiolucent area. B, B', Endodontic therapy completed. C, C', One year after treatment; total bone regeneration. Courtesy of Dr. Barry Jaye, Brockton, MA.

**Guided Tissue Regeneration
and Endodontic Surgery:
Combined Procedure**

The successful application of guided tissue regeneration (GTR) and periapical surgery has been reported in a number of case reports (Tseng and colleagues, 1996; Brugnami and Mellonig, 1999). Histologically, Douthitt and colleagues (2001) reported significantly greater alveolar bone and periapical bone in the GTR group. Britain and colleagues (2005) in an in vitro study found that bioabsorbable membranes (Bio-Gide® [Osteohealth, Shirley, NY]) alone or in combination with an organic bovine bone matrix (Bio-Oss® [Osteohealth, Shirley, NY]) resulted in increased bone and periodontal ligament.

The cases presented here are typical of what is achievable when GTR and endodontic surgery are combined (Figures 12-24 and 12-25).

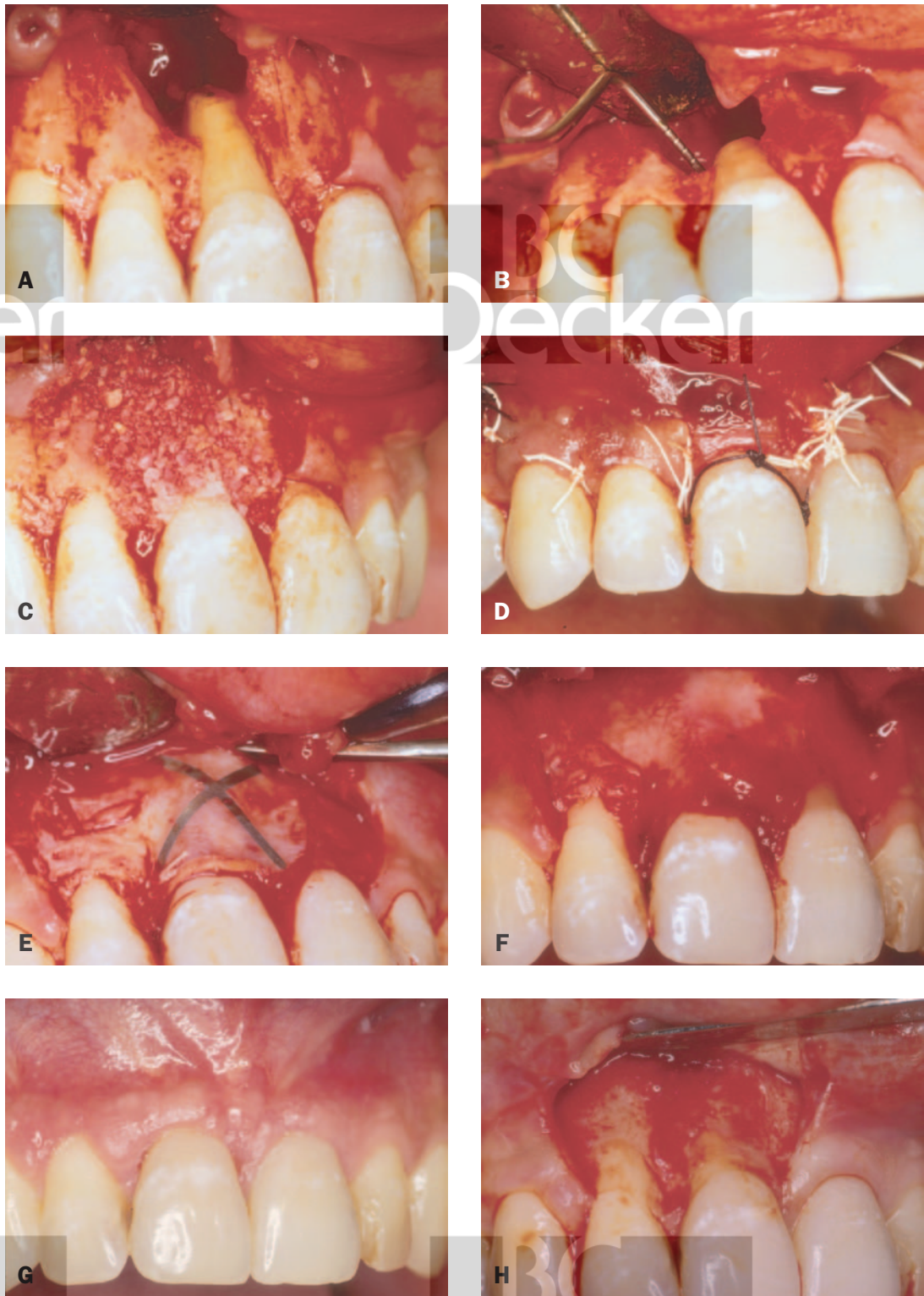


FIGURE 12-24. Regeneration for treatment of endodontic lesions. A, Periapical lesion with bony dehiscence over buccal root of tooth #8. B, Depth of apical lesion explored with periodontal probe. C, DFDBA placed. D, Flap sutured after membrane placement. E, Titanium reinforced membrane exposed at time of removal. F, Membrane removed showing complete healing with osteoblastic and pre-osteoblastic tissue. G, 1 year post treatment. H, Re-entry at 1 year. Note complete bone regeneration. Courtesy of Federico Brignami, Rome, Italy).

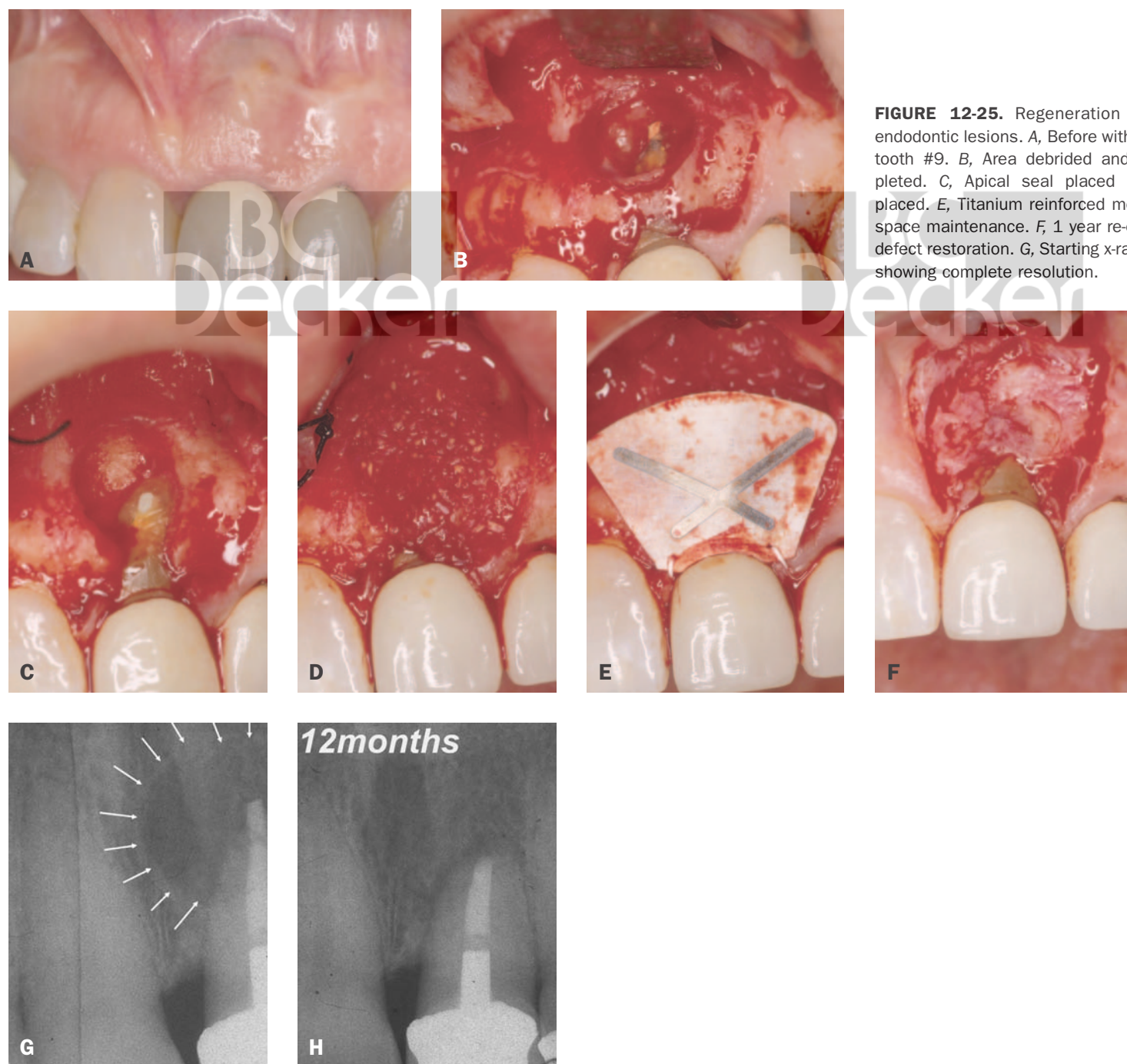


FIGURE 12-25. Regeneration for treatment of endodontic lesions. A, Before with large swelling over tooth #9. B, Area debrided and endodontics completed. C, Apical seal placed in root. D, DFDBA placed. E, Titanium reinforced membrane placed for space maintenance. F, 1 year re-entry with complete defect restoration. G, Starting x-ray. H, 12-month x-ray showing complete resolution.



Visual Perception

Perception

Perception is the psychological response, organization, and interpretation of sensory stimuli (sight, smell, taste, touch, and hearing). It is culturally based and subjective, which gives rise to the truism “Beauty is in the eye of the beholder.” The comparison of stimuli with our previous experiences, which are then interpreted, is known as *precept*. Esthetics is derived from the Greek *aesthesis*, meaning perception. The science of visual perception or esthetics is the study of sensory stimuli and response. Visual perception is a prerequisite for esthetics, as is visual examination a requirement for clinical investigation (Rufenacht, 1990). Understanding the fundamental objective criteria of esthetics is a basic requirement for understanding and appreciating beauty.



FIGURE 13-1. Objects made visible by contrast.

Composition

Composition is the study of the relationship between objects made visible by contrasts in color, line, or texture (Figure 13-1). Contrast allows our eyes to “see” or differentiate. As contrast increases, so does visibility if there is enough light to illuminate. In dentistry, we are concerned with facial, dentofacial, and dentogingival compositions (Lombard, 1973).

Unity

The prime requisite of composition is unity (Lombard, 1973). Unity is the ordering of differ-

ent individual parts of the composition to give the effect of the whole. The whole is greater than the sum of the individual parts and is now a new entity, as a musical note is to a sheet of music or an individual tooth is to a segment of teeth (Figure 13-2).

Unity may be subdivided into stagnant and dynamic unity (Rufenacht, 1990):

Stagnant unity (Figure 13-3)

1. Geometric shapes
2. Nonliving
3. Inert (no motion)
4. Repetitions
5. Examples: crystals, snowflakes, water droplets



FIGURE 13-2. The individual element is different when made part of the whole.



FIGURE 13-3. Stagnant unity is nonliving, inert (no motion) and repetitious.

Dynamic unity (Figure 13-4)

- 1. Growing
- 2. Living
- 3. Active
- 4. Diversity
- 5. Examples: plants, animals

“Static designs are based on a regular repetitive pattern and on the unchanging curve of a circle, whereas the dynamic designs are like the flowing continuity of the logarithmic spiral with its generating nucleus” (Graves, 1951) (Figures 13-5 and 13-6).

Dominance

Dominance is the prime requisite for providing unity, just as unity is the prime requisite for pro-

viding good composition. Dominance may be static (monotonous) or dynamic (diverse).

Static dominance is represented by similar elements, such as crystals or small teeth, which tend to be weak. Dentofacial dominance can be enhanced by making the teeth longer, whiter, and/or more diverse (Figure 13-7).

Dynamic dominance is represented by a shape, color, or line that dominates within a group of elements. In dentistry, the mouth dominates the face and the central incisors dominate the anterior tooth segment (Figure 13-8).

Forces: Cohesive versus Segrative

A good composition is composed of varying degrees of two opposing forces, referred to as cohesive and segrative.

Cohesive forces tend to unify a composition by (Gulamerian, 1963; Lombard, 1973): (Figure 13-9)

- 1. Repetition of shape, color, or line
- 2. A border about an object
- 3. An object in a pattern
- 4. Monotony

Segrative forces allow for diversity of composition by providing for (Figure 13-10)

- 1. Asymmetry
- 2. Interesting placement of elements

Dentofacial harmony requires that the cohesive and segrative forces be in balance (Rufennacht, 1990) (Figure 13-11).



FIGURE 13-4. Dynamic unity is active, living, and mobile

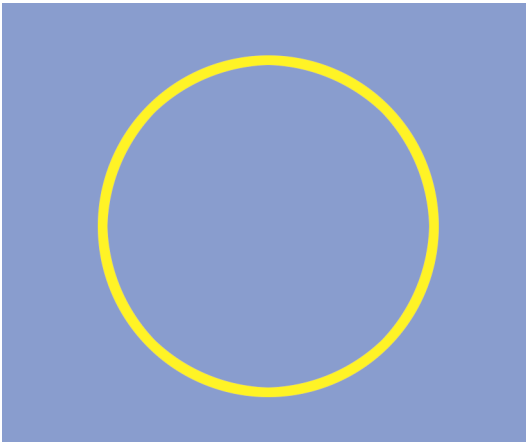


FIGURE 13-5. Static design, the circle is represented by a circle, absolute unity without variety.



FIGURE 13-6. Dynamic design is represented by Hogarth's line of beauty providing absolute beauty with absolute unity. The line is never the same at any two points yet never deviates from the core structure.



FIGURE 13-7. Static dominance of small teeth is enhanced by lengthening and whitening of teeth.



FIGURE 13-8. Facial and dental elements showing their dominant features, the mouth, and central incisors respectively.



FIGURE 13-9. A border about objects like the lips about the teeth frame the individual elements and tie them together.

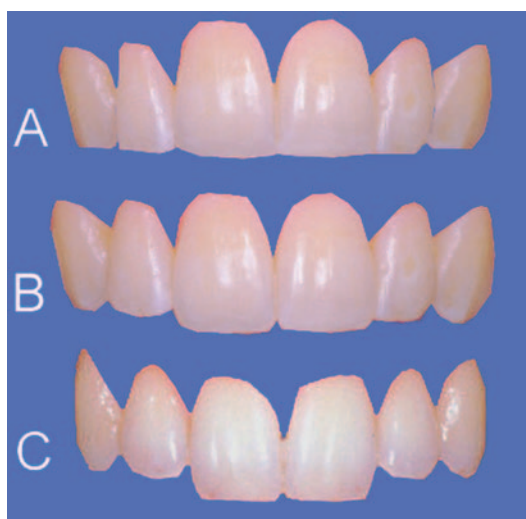


FIGURE 13-10. A, Straight line incisal edges lack interest or unity. B, and C, show asymmetry, diversity, and variety. Note that too often the straight incisal line is used for convenience.



FIGURE 13-11. The relationship of the facial, dental facial, and dental elements are both uniform and diverse providing a pleasing result.

Symmetry

Symmetry refers to the regularity of objects or teeth as they move away from the center point and is referred to as horizontal or radiating symmetry:

Horizontal or running symmetry (Figure 13-12)

1. Cohesive
2. Monotonous
3. Similarity of all objects
4. Right and left sides are identical

Radiating or dynamic symmetry (Figure 13-13)

1. Segrative
2. Dynamic/interesting
3. Right and left sides are mirror images

Composition requires symmetry for balance, equilibrium, and visual balance to exist.

Dentofacial composition requires the introduction of radiating symmetry to create a positive psychological response, and whereas horizontal symmetry is the most important factor in facial composition, radiating symmetry takes precedence in the dentofacial view.



FIGURE 13-12. Horizontal symmetry represented by small, similarly shaped teeth.



FIGURE 13-13. Radiating symmetry showing diversity and asymmetry of prosthetically restored teeth.

Balance and Equilibrium

Balance is the equalization or exact adjustment of opposing forces with no one force out of proportion to another. Balance, when applied to esthetics, is termed *equilibrium*, which also encompasses perception for interpreting visual and special relationships. An imbalance in the color, size, and/or shape of teeth produces tension and is the result of induced forces.

Induced Forces

Induced forces are tensions produced by an object imbalance, creating a desire on the part of the beholder to alter or move the object so as to induce equilibrium. The disk in the corner of the square (Figure 13-14) is representative of this phenomenon. There is tension produced on the viewer's part that can be relieved only by moving the disk to the center or by balancing it with

another disk. This tension is a real part of our percept (Lombard,1973) and because it has both magnitude and direction is considered to be an induced force (Figure 13-15).

Structural Map

A structural map is the most stable position of an object in the center, where it is being repelled by its borders (Figure 13-16). Just as the disk is most stable in the center of the square, so is the dental midline the most stable point of the dentofacial and dentogingival complexes (Figure 13-17):

Therefore, objects in balance are (Figure 13-18)

- 1. Peaceful
- 2. Stable
- 3. Planned
- 4. Permanent
- 5. Completed

Objects in imbalance are (Figure 13-19)

- 1. Tense
- 2. Unstable
- 3. Accidental
- 4. Transitory
- 5. Unfinished

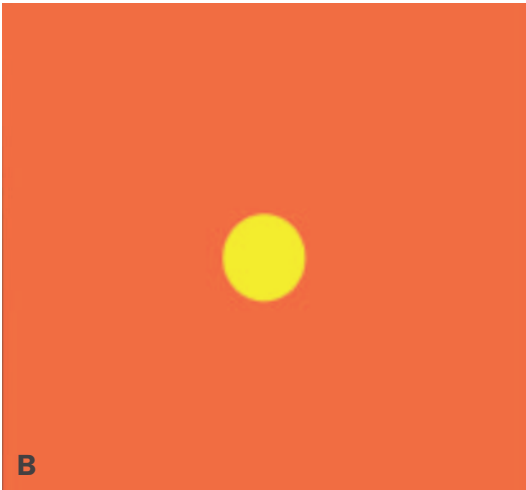
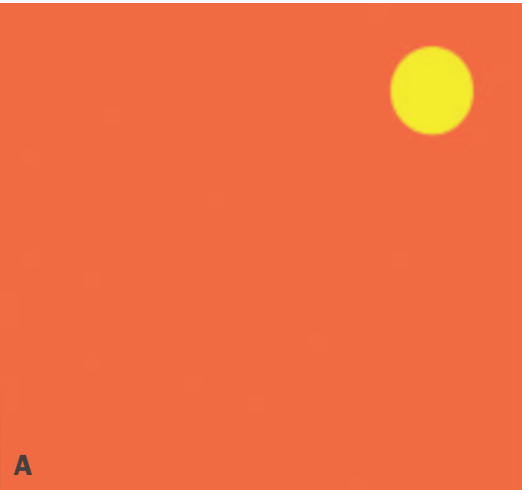


FIGURE 13-14. Induced forces. A, The disk is positioned off center. Inset, The offset position promotes a desire to move the objects (arrows indicate force and direction); B, and C, balance is achieved and reduced with a stable disc placement or balanced pairs.

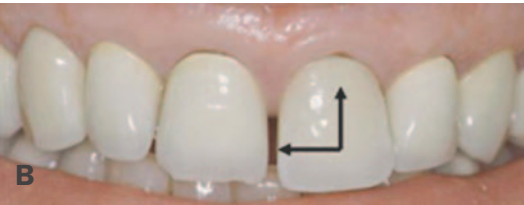


FIGURE 13-15. A, The central incisor is off center. B, The arrows indicate the force and magnitude of induced forces. C, Tooth positioned correctly and tension is eliminated.

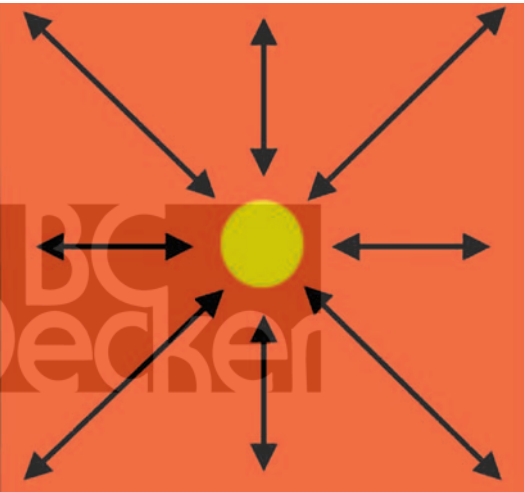


FIGURE 13-16. Structural map. The disk is in the most stable balanced point.

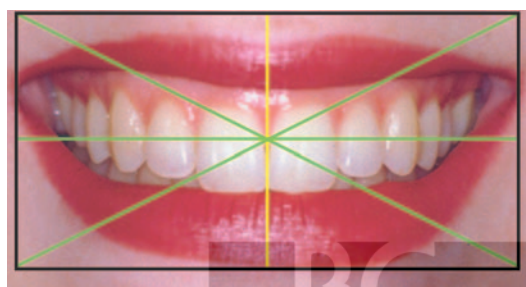


FIGURE 13-17. Structural map showing the dental midline as the most stable point.

Finally, balance must also be considered in terms of the visual weight (color and direction) that exists on either side of a fulcrum. The objects closest to the center have less impact than objects farther from the fulcrum.

Lines

Facial, dentofacial, and dentogingival esthetics are determined by harmony, integration, and proportion of various lines. As we shall see in Chapter 14,



FIGURE 13-19. Imbalance of color and space before (A) and after (B) correction of color and space closure providing stability and harmony.



FIGURE 13-18. Balance vs imbalance. Note the difference between two smiles. A, balance. B, Imbalance.

Esthetic Structural Analysis, our perception of these undrawn lines determines beauty and guides our dental reconstructions (Figure 13-20).

Parallel lines are the most harmonious relationship that exists because they exhibit the least amount of contrast or conflict. Conflict increases as asymmetry or divergence increases.

Perpendicular lines provide the strongest perceptual relationship owing to the greatest amount of conflict.



FIGURE 13-20. Note the contrast of tension when viewing parallel versus perpendicular line.

Proportion

Proportionality should provide for unity, variety, and interest where the individual elements are both cohesive and segregative (Figure 13-21). This satisfactory division of a surface into separate objects of contrasting size and shape that are still related to each other is termed the repeating ratio.

The Greeks (Pythagoras) developed a repeating mathematical ratio for beauty of 1.618 to 1, which became known as the golden mean. The Parthenon was built exclusively using the repeating ratio and is considered by many to be one of the most beautiful architectural creations.

The golden proportion appears to provide the satisfactory integration of diversity versus unity and cohesive versus segregative forces. When the golden proportion cannot be applied, a constant ratio should be sought.

Cosmetics versus Esthetics

Cosmetics is the superficial covering up or over of the body, face, or teeth. Dental cosmetics is confined to those cleansing and whitening agents used for the oral cavity and teeth. Esthetics, on the other hand, is the application of varying modalities of treatment to physically alter the jaws, teeth, and gingival tissue to achieve a more pleasing appearance, such as in the case of orthodontics and orthognathic surgery.



FIGURE 13-21. Repeated ration and golden proportion.



Esthetic Structural Analysis

The Dental Smile

Fundamentals of Esthetics

It has often been stated that the eyes are the windows to the soul. If that is the case, the dentofacial complex or mouth is the key to defining an individual's dynamic personality. The lips are the largest and most mobile part of the facial complex and the key facial element when viewed by others. Is it any wonder, then, that an unsightly smile can have a profound negative impact on an individual's personality, outlook, emotions, and relationships with others? Therefore, the primary goal of esthetic dental treatment is the restoration of a natural, healthy, and esthetic appearance from an otherwise damaged dentition (Rifkin, 2000).

This section attempts to define the basic fundamentals of esthetics and how they relate to smile enhancement. Because facial beauty is based on both cultural and subjective analysis, it is difficult to objectify because each culture has its own standards of beauty, whether it is the tiny feet of the Chinese nobility, the classic Greek proportionality that facial width should equal five times the width of one eye, or our youthful desire for a prominent smile with bright teeth (Goldstein, 1998). Yet we must attempt to do so.

It cannot be emphasized enough that the dentogingival complex (teeth and gingiva) is but one part of the overall facial and dentofacial esthetic paradigm and therefore must be evaluated not only by itself but also in relation to the total esthetic complex. Without such an evaluation, true esthetic dentistry or beauty cannot be achieved. It must be remembered that when the face is viewed from a distance, the overall symmetry balance and proportion are important. The individual facial elements gain in importance only as proximity decreases (Lumbard, 1973). Therefore, the most common mistake made by dentists during their initial examination is to first examine the oral cavity.

Esthetic Analysis: Composition

- I. Facial
- II. Dentofacial
- III. Dentogingival
- IV. Dental

I. Facial Composition

Frontal View

A. Proportionality (Figure 14-1)

1. VERTICAL DIVISION (Annette and Bergman, 1992a, 1992b; Chiché and Pinault, 1994; Moskowitz and Nayar, 1995; Rifkin, 2000)

Using the following four key determinants:

- Trignon (forehead)
- Opharic (eyebrows)
- Subnasion (nose)
- Gonion (chin)

The face is ideally divided into equal thirds (Figures 14-2A and B):

- Upper: trignon to opharic
- Middle: opharic to subnasion
- Lower: subnasion to gonion

The lower third of the face is further divided into two unequal parts (Rifkin, 2000):

- a. Subnasion to commissures of the lips is equal to one-third or 18 to 20 mm from the subnasion to the upper lip
- b. Commissures of the lips to the gonion is equal to two-thirds or 36 to 40 mm from the lower lip to the gonion

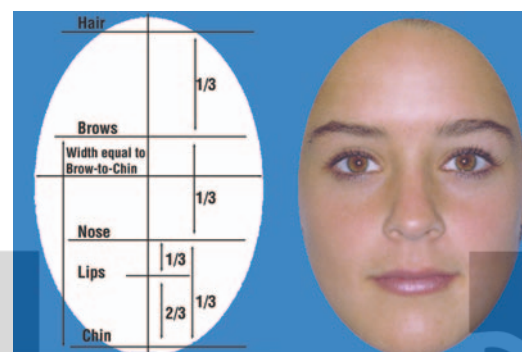


FIGURE 14-1. Facial proportions. Artistic horizontal and vertical reference lines are established prior to drawing. They permit the interrelationship of the individual parts. The relationship is one that maximizes harmony and symmetry.

Changes in lower third of the face (Arnett and Bergman, 1993) (Figure 14-3)

- Increase lower one-third height
 - a. Vertical maxillary excess
 - b. Class III malocclusion
- Decreased lower one-third height
 - a. Vertical maxillary deficiencies
 - b. Mandibular retrusion bites

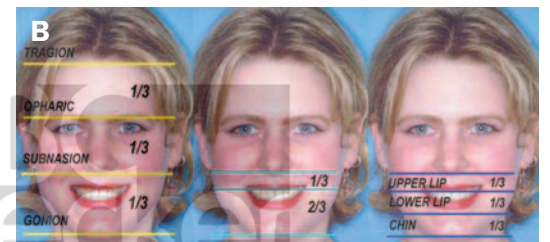


FIGURE 14-2. Facial divisions. The face is divided into thirds, with the lower third further subdivided into either (A) two unequal parts or (B) thirds.



FIGURE 14-3. Lower face alterations. Changes in the lower third of the face are visualized by changes in the proportions.

2. **HORIZONTAL LINES.** (Figure 14-4) The key horizontal lines for esthetic evaluation are as follows:

- Interpupillary line (primary)
- Commissural line (primary)
- Opharic line (secondary)

The “parallelism” of these horizontal lines is paramount for achieving pleasing esthetics (Ahmad, 1998). Horizontal parallelism is responsible for the following:

- Unifying facial composition
- Producing cohesive forces
- Reducing tension

It should be noted that a single line is not as important as the general parallelism of all of the lines. Excessive asymmetry or divergence produces tension and a lack of harmony, balance, and proportion, which diminishes beauty.

Note that if the pupils are uneven, then the interpupillary line is drawn parallel to the floor, bisecting only one eye.

Kokish (1999), in a comparative study of dental esthetics among orthodontists, general dentists, and lay people, found that up to a 3 mm horizontal midline shift was not nearly as disturbing as a slight shift in vertical angulation. A horizontal shift does not alter the general parallelism of the facial components, whereas small changes in vertical angulation alter the parallelism and are segregative (Figure 14-5).



FIGURE 14-4. Horizontal lines. The facial and dentofacial lines should always be parallel with each other.

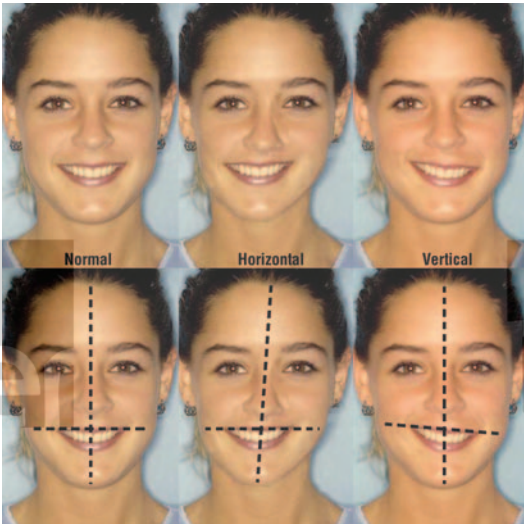


FIGURE 14-5. Midline shift. Horizontal facial and midline shift is not as disturbing as a small shift in vertical angulation. (Horizontal shifts still result in parallelism, whereas vertical angulation results in a loss of parallelism.)

B. Balance and Symmetry. THE FACIAL MIDLINE Facial symmetry is defined by the facial midline (Rifkin, 2000). The midline runs through the center of the face and a philtrum of the lip (cupid’s bow), dividing it into right and left sides. The more symmetric and identical the sides, the closer they come to bilateral duplication or mirror images, the more inherently harmonious and beautiful the face (horizontal symmetry). This is the opposite of the dental midline, which seeks beauty through diversity (radiating symmetry).



FIGURE 14-6. The facial midline. The facial midline bisects all of the other lines and is segregative.



FIGURE 14-7. Anatomic interrelationships. In these figures, we see how the different parts of the facial and dentofacial elements are interrelated horizontally.

The facial midline also runs perpendicular to the horizontal lines and stands in stark contrast to their cohesiveness (Golub, 1988) (Figure 14-6). The midline, unlike the horizontal parallel lines, is

- Segregative
- Tension producing

In many individuals, the midline may vary without deleterious effects (Rufenacht, 1990).

Facial, dentofacial, and dental compositions have a number of relationships that can be evaluated automatically and according to the golden proportion (Figures 14-7 and 14-8).

These anatomic relationships and proportionalities should serve as a basis in diagnosis and treatment planning in esthetic reconstruction periodontal prosthetic cases.

SAGITTAL (LATERAL) VIEW. The facial and sagittal views should have the same facial and dentofacial horizontal proportions (Figure 14-9). But unlike the facial view, the lateral view provides us with a way of analyzing skeletal problems and determining a facially generated occlusion (Arnett and Bergman, 1993a, 1993b; Rifkin, 2000; Spear, 1991; Strub and Turp, 2001; Subtelny, 1959).

Sagittal Soft Tissue Facial Form Diagnostic Factors:

- Orthodontic and orthognatic problems
- Phonetics: “F,” “V,” “S,” “M”
- Tooth position and inclination
- Lip support
- Horizontal smile analysis: natural and strained
- Lip relationship or lip support

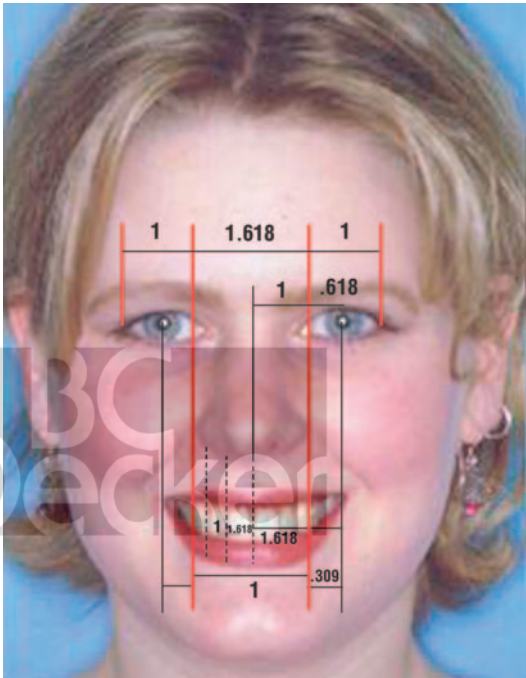


FIGURE 14-8. Golden proportion. The various parts of the facial, dentofacial, and dental elements are proportionally related, which permits an esthetic analysis among different individuals.



FIGURE 14-9. Sagittal proportions. The sagittal facial divisions should be the same as those facially.

FACTORS USED FOR SAGITTAL FACIAL ANALYSIS.
(Figure 14-10)

- Direct visualization (Figure 14-10A)
- Nasolabial line angle (Figure 14-10B)
- Ricketts' line angle (see Figure 14-10B)
- Angle of soft tissue facial convexity (Figure 14-10C)
 - a. Glabella/subnasale/pogonion (G-S-P)
 - b. Nasion/subnasale/pogonion (N-S-P)
 - c. Nasion/tip of nose/pogonion (total soft tissue profile) (Subtelny, 1959)

Note: The G-S-P is the most commonly used reference point.

- Eye-ear plane (Frankfort horizontal) (see Figure 14-10C)
- A plane passing through orbital points and the trignon (rounded eminence anterior to the external auditory meatus)
- Orbital plane (see Figure 14-10C)
- A line passing through the orbital points at right angles to the eye-ear plane (Frankfort horizontal). Normally, this line runs through the cheilion (corner of the mouth) and gnathion (lowest most anterior point on the body of the mandible)

1. Visualization

Direct visualization is helpful in the following:

- Smile line
- Lateral extent of smile line
- Lip line: high, medium, low
- Gummy smile: greater than 3 mm of gingival display
- Incisal position
- Phonetics: "F," "V," and "S" consonants
- Curvature of maxillary centrals
- Tooth-lip support relationship
 - a. Normal: gingival two-thirds (Maritato and Douglas, 1964)

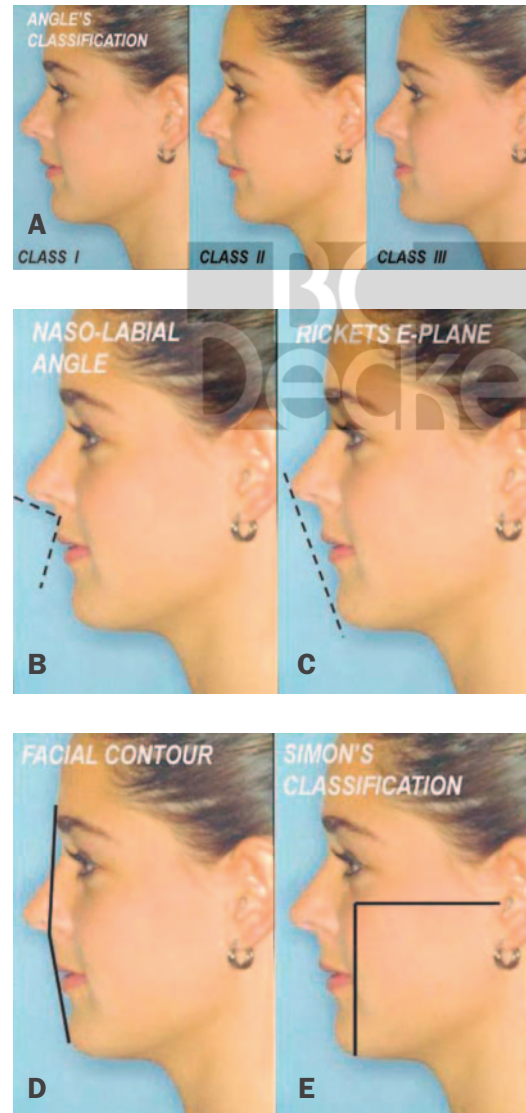


FIGURE 14-10. Sagittal analysis. A, Direct vision. B, Nasolabial line angle. C, Ricketts' line angle. D, Angle of soft tissue contour. E, Simon's classification.

- b. Gingival and cervical third: Class III, Class II, Division II
 - c. Incisal edge: Class II, Division I, thin lips (Pound, 1962)
- Inadequate vertical dimensions
 - a. Lower lip more forward than upper lip
 - b. Upper lip rolls in
 - c. Deep lower lip concavity
 - d. Extension of angle of the mouth
2. Nasolabial line angle (NLA) (Figure 14-12)

The angle formed at the subnasale by two lines. The first runs tangent to the inferior border of the nose, and the second runs tangential to the lip. The normal angle is 85 to 105° (85–95° male; 95–105° female).

FIGURE 14-11. Direct visualization. A, A', Facial and lateral views of lips at rest. The clinician should note the amount of tooth exposure facially, the position of the upper lip and the relationship of the lips to each other. B, B', Facial and lateral views of unstrained smile. C, C', Facial and lateral views of strained smile. Note the significant change from the unstrained smile. The clinician should evaluate the position of the central incisors, the lip line, the degree of tooth and gingival exposure, incisal edge position and incisal edge and lip curvature in both the unstrained and strained smiles. D, D', Phonetic evaluation of tooth position for F and V respectively. Note teeth outside the vermillion boarder for F and inside the vermillion boarder for V.



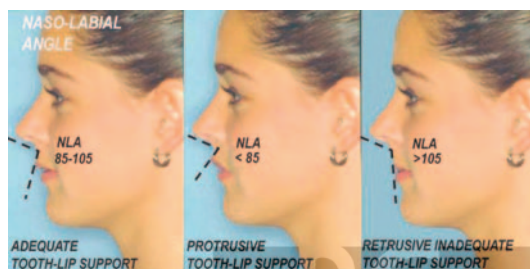


FIGURE 14-12. Nasolabial line angle.

This angle can be used to help determine the correct anteroposterior (AP) position or inclination of the maxillary anterior teeth. All procedures should place this angle in the cosmetically desirable range of 85 to 105° (Arnett and Bergham, 1993).

3. Ricketts' line angle or E-plane (Figure 14-13)

This is a line drawn from the tip of the nose to the most anterior part of the chin (pogonion). The maxillary and mandibular lip positions are 4 mm and 2 mm, respectively, from this line. It is useful in determining

- Mandibular protrusions or retrusions
- Maxillary protrusions or retrusions
- Combinations

4. Angle of facial convexity or soft tissue profile (Figure 14-14)

- Normal range
 - G-S-P has an angle of 165 to 175° (Arnette and Bergham, 1993b).
 - N-S-P has an angle of 161 to 165° (Subtelny, 1959)
- Abnormal
 - Concave profile (angle > 175° G-S-P)
 - Vertical maxillary deficiency (rare)
 - Mandibular protrusion (common)
 - Convex profile (angle < 165° G-S-P)
- Maxillary protrusion (rare)
- Vertical maxillary excess (common)
- Mandibular retrusion (common)

5. Simon classification (Hughes, 1951) (Figure 14-15)

This classification is based on the relationships of the cheilion (C) (corner of the mouth), subnasion (S), and gnathion (G)

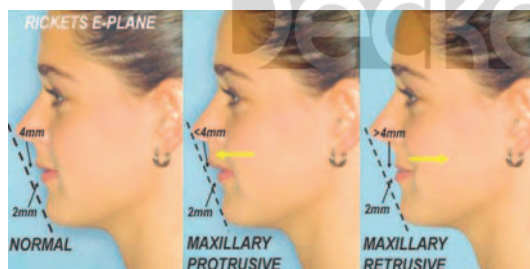


FIGURE 14-13. Ricketts' E-plane.



FIGURE 14-14. Facial contour. A, Normal. B, Convex. C, Flat.

(lowest most anterior point on body of mandible) to eye-ear and orbital planes. The orbital plane normally passes through the cheilion to the gnathion. Protraction and/or retraction of the maxillary and/or mandibular segments will result in an altered C-S-G relationship.

The combination of the angle of facial convexity (G-S-P), Simon classification, Ricketts' E-plane, and the NLA will allow the clinician to diagnosis skeletal and dental anomalies that affect facial form.

The American Association of Oral and Maxillofacial Surgeons' surgical update (1999) lists the following common dentofacial deformities that might be recognized:

Maxillary Deformities:

1. Maxillary hyperplastic vertical maxillary excess or "gummy smile": overgrowth of the maxillary alveolus in an inferior direction
2. Maxillary AP excess: protrusive maxilla; overgrowth in an anterior horizontal direction
3. Maxillary hyperplastic vertical maxillary deficiency: edentulous look showing no teeth; showing lower face
4. Maxillary AP deficiency: inadequate growth in an anterior direction; usually seen with cleft palate and cleft lip
5. Apertognathia or "open bite": skeletal deformity demonstrating tongue thrust; often speech pattern affected

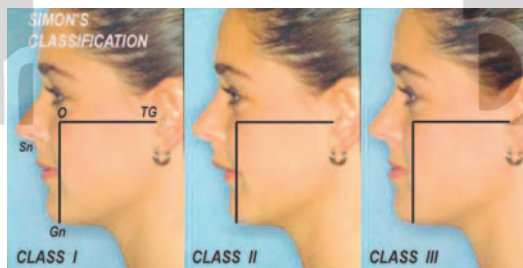


FIGURE 14-15. Simon's classification. The angle of the mouth moves posteriorly in retrusion cases and anteriorly in protrusion cases.

6. Alveolar cleft: usually occurs with a cleft lip and cleft palate

Mandibular Deformities:

1. Mandible hyperplastic mandible AP excess: pragmatism; Class III malocclusion
2. Macrogenia: overgrowth of chin in a vertical or anterior direction
3. Mandible hyperplastic mandible AP deficiency or "Andy Gump" (very common deformity): deficient anterior growth of mandible; Class II malocclusion
4. Microgenia: undergrowth of chin in a vertical or anterior direction
5. Mandible asymmetry: usually excessive growth of one condyle; chin and mandibular midline shift to opposite

Combination Maxillary and Mandibular Deformities:

Long face syndrome: overall increase in facial height; usually a combination of vertical maxillary excess and mandibular deficiency

II. Dentofacial Composition. The interrelationship between the lips, teeth, and facial structures represents the dentofacial components. For balance, symmetry, beauty, and proportion, the facial and dentofacial elements must be in harmony.

A. Horizontal Components (Figure 14-16). The principal horizontal lines for esthetic evaluation are as follows:

1. Interpupillary line
2. Commissural line
3. Occlusal line

Factors that adversely affect the occlusal line relationships producing asymmetry are

1. Attrition
2. Overeruption
3. Altered active eruption
4. Pathologic migration
5. Skeletal problems resulting in asymmetric growth of the mandible or maxilla
6. Orthodontic problems

Again, the importance of parallelism between the horizontal lines cannot be overstated.



FIGURE 14-16. Critical dentofacial horizontal components and facial midline relationships.

ed. Parallelism is necessary for harmony, balance, and esthetics.

B. Vertical Components (see Figure 14-16)

1. FACIAL MIDLINE. The facial midline runs perpendicular to the
- Interpupillary line
 - Commissural line
 - Occlusal line
- In general, it should coincide with the
- Philtrum of the lip (cupid's bow)
 - Dental midline

2. DENTAL MIDLINE. The dental midline perpendicular to the interpupillary line offers one of the most striking facial contrasts and serves to anchor the smile to the face (Golub, 1988). A properly positioned midline may also be used to divert attention away from facial asymmetry (Golub, 1988; Rufenacht, 1990; Chiche and Pinault, 1994).

The facial and dental midlines coincide about 71% of the time, with women having a slightly higher percentage (71.3%) than men (68.8%) (Table 14-1 and Figure 14-17). The maxillary and mandibular midlines are coincidental only 27.8% of the time, with men (26.9%) and women (28.3%) showing no significant differences (Table 14-2 and Figure 14-18). Therefore, whereas placing the dental midline slightly off center of the facial midline is acceptable and will increase diversity (Golub, 1988), the use of the mandibular midline as a reference for determining the maxillary midline is to be avoided.

C. Lips. The lips provide the framework for the dental elements. They are like a picture frame that provides a border for a piece of artwork. The lips separate and isolate the individual dentogingival elements from the other facial structures, allowing them to possess independent characteristics. In other words, facial form need not dictate dental form (Lombard, 1973).

Lombard (1973) further noted that a picture being hung on a wall need not possess the same characteristics or elements as the wall it is being hung on because the frame separates it from the



FIGURE 14-17. Lack of coincidence between facial and dental midlines

wall, permitting the elements within to form a separate organized entity. The lips frame the dentogingival elements, separating them from the facial elements (the wall) and thus permitting them to form a separate organized entity. From a distance, only the general outlines (facial and dental midlines and horizontal parallelism) dominate; the individual elements are not a factor. In close proximity, the eye is drawn to the contents within the lips, and it is impossible to give careful consideration to the teeth and face at the same time. Therefore, facial form and tooth form need not correspond (Figure 14-19).

Note: This is most easily visualized by standing in close proximity to someone.

The lips exist in a static and a dynamic position:

1. Static position (rest) (Figure 14-20). The lips are positioned at rest, slightly parted, the teeth are out of occlusion, and the musculature is relaxed.
2. Dynamic position (smiling) (Figure 14-21). Contraction of the perioral musculature retracts the corners of the lips, exposing the dentogingival elements. The degree of exposure varies with the following:
 - a. Size, shape, and fullness of the lips
 - b. Degree of contraction

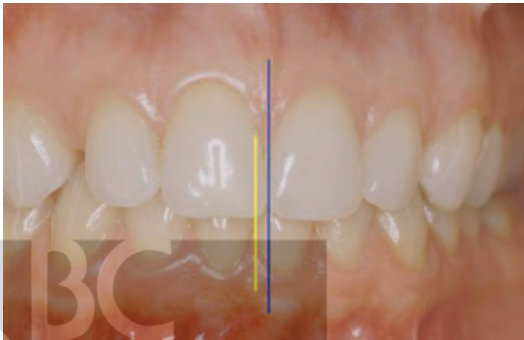


FIGURE 14-18. Lack of coincidence between maxillary and mandibular midlines.

- c. Nature and size of perioral musculature
- d. Skeletal makeup
- e. Size, shape, and position of the dental components

The lips may be classified as (Figure 14-23)

1. Thick or full
2. Medium
3. Thin

The upper lip is generally supported by the gingival two-thirds of the central incisor, with the incisal edge helping to support the lower lip (Rufenacht, 1990). Thin and/or protruding lips require more incisal edge support than thick lips (Pound, 1962) (Figure 14-24).

Lieb and colleagues (1967) found an age shift in the anterior position of the lower lip in relation to the upper lip when viewed sagittally. Physiologically, this is due to a loss of muscle tone and strength. It was further accentuated occlusally by a loss of occlusal vertical dimension (Figure 14-25).

Note: These changes were found to be reversible with interceptive prosthetic treatment.



FIGURE 14-19. The individual elements become important the closer the proximity. Facial and dental elements are difficult to view together in close proximity.

Table 14-1 Number of Subjects Whose Dental Midlines Coincided with the Median Line of the Philtrum				
No. of Subjects	Does		Does Not	
	Coincide	%	Coincide	%
500	352	70.4	148	29.6
Adapted from Miller and colleagues (1979).				
Note: 95% confidence limits extend from 66.4 to 74.4%.				

Table 14-2 Number of Subjects in Whom the Midline of the Maxillary Dentition Coincided with the Mandibular Midline				
No. of Subjects	Does		Does Not	
	Coincide	%	Coincide	%
500	352	70.4	148	29.6
Adapted from Miller and colleagues (1979).				
Note: 95% confidence limits extend from 23.9 to 31.7%.				



FIGURE 14-20. Lips slightly parted in a static rest position.



FIGURE 14-21. Lips retracted in a smiling position.

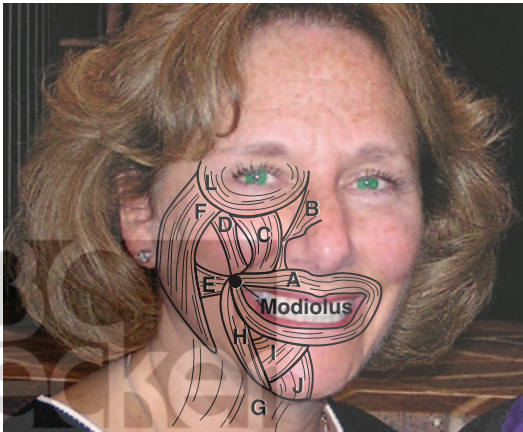


FIGURE 14-22. Muscles associated with lip movements in smile zone. A, Orbicularis oris. B, Levator labii superioris. C, zygomaticus minor. D, Zygomaticus major. E, Buccinator. F, Masseter. G, Platysma. H, Depressor anguli oris. I, Depressor labii inferioris. J, Mentalis. **Modiolus** is the convergence of the five muscle groups at the corner of the mouth.



FIGURE 14-23. Lip classification.

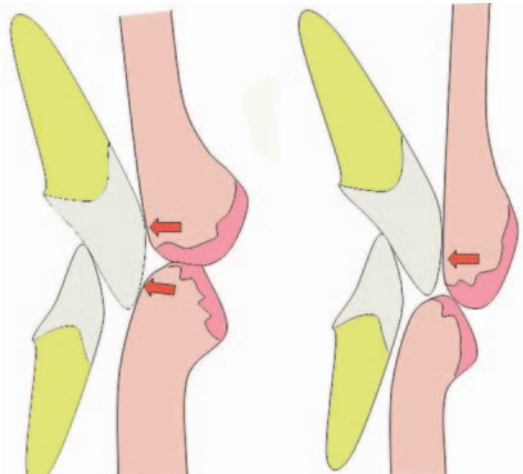


FIGURE 14-24. Lip support: A, Normal lip support by gingival $\frac{2}{3}$ of the tooth. B, Thin lips which require incisal edge support.

Smiles may be classified as (Moskowitz and Nayyar, 1995)

1. Crescent shaped: both ends curved up (convex)
2. Half-moon shaped: straight upper lip and curved lower lip.
3. Reversed: both ends curved down (concave)
4. Rectangular

LARS FACTORS. Lip position is determined by four factors:

1. Lip morphology
2. Age
3. Race
4. Sex

These have been referred to as the LARS factors (Vig and Bruno, 1972).

1. **LIPS.** The amount of tooth exposure is determined by the size of the musculature, the fullness of the lips, and lip length. Normal lip length is 16 to 24 mm. A short upper lip (< 15 mm) will display all of the dentogingival complex, whereas a long upper lip (≥ 24 mm) will significantly reduce tooth exposure (Table 14-3).

2. **AGE.** Tooth exposure is inversely proportional to age (Table 14-4). Aging reduces muscular elasticity and tonicity, resulting in a longer lip

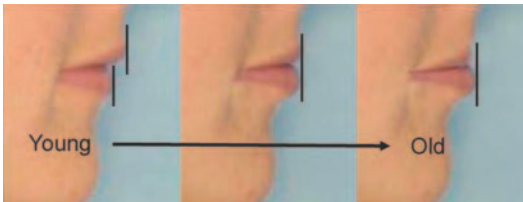


FIGURE 14-25. Lip change as one gets older.

length with diminished mobility and greater exposure of the mandibular teeth. This results in accentuation of the aging process, with deepening of the facial grooves in the lower third of the face (Ahmed, 1998). Attrition of the anterior teeth and loss of anterior tooth support are also contributors to the problem (Lieber and colleagues, 1967).

With aging and loss of vertical dimension, the lower lip begins to protrude in front of the upper lip. The restorative dentist must therefore view the lips not only facially but laterally as well. This is to make sure that the upper lip is anterior to the lower lip. If not, the lips will require additional incisor tooth support.

Table 14-3 Tooth Exposure by Length of the Upper Lip			
Mean Amount of Tooth Exposed (mm)			
Upper Lip	Upper Lip Length (mm)	Maxillary Central Incisor	Mandibular Central Incisor
Short	10–15	3.92	0.68
Medium	16–20	3.44	0.77
Medium	21–25	2.18	0.98
Long	26–30	0.93	1.95
Long	31–35	0.25	2.25

Adapted from Vig and Bruno (1978).

Table 14-4 Tooth Exposure by Age		
Mean Amount of Tooth Exposed (mm)		
Age Group (yr)	Maxillary Central Incisor	Mandibular Central Incisor
Up to 29	3.37	0.51
30–39	1.58	0.80
40–49	0.95	1.96
50–59	0.46	2.44
60+	–0.04	2.95

Adapted from Vig and Bruno (1978).

3. *RACE*. There were no significant differences in tooth exposure between black and Asian races, with Caucasians having somewhat greater exposure (Table 14-5).

4. *SEX*. There were significant differences in tooth exposure between men and women (Table 14-6).

III. Dentogingival Elements. Although horizontal symmetry is the most important factor in facial composition, radiating symmetry takes precedence in the dentogingival view (Ahmad, 1998). Studer and colleagues (1996) and Goldstein (2002) noted a number of dentogingival esthetic elements for consideration in general patient evaluation and complex periodontal prosthetic cases (Figure 14-26):

- Dental midline
- Gingival line
- Occlusal plane
- Incisal edge curvature
- Smile line
- Curvature of the lower lip
- Contact points
- Gingival height of contour
- Gingival embrasures
- Incisal embrasures
- Axial inclination
- Buccal corridor

Note: All dentogingival elements must interrelate with the interpupillary line and facial midline (Figure 14-27).

Table 14-5 Tooth Exposure by Race		
Mean Amount of Tooth Exposed (mm)		
Race	Maxillary Central Incisor	Mandibular Central Incisor
Caucasian	2.43	0.98
Black	1.57	1.42
Asian	1.86	1.58

Adapted from Vig and Bruno (1978).

Table 14-6 Tooth Exposure by Sex		
Mean Amount of Tooth Exposed (mm)		
Sex	Maxillary Central Incisor	Mandibular Central Incisor
Male	1.91	1.23
Female	3.40	0.49

Adapted from Vig and Bruno (1978).

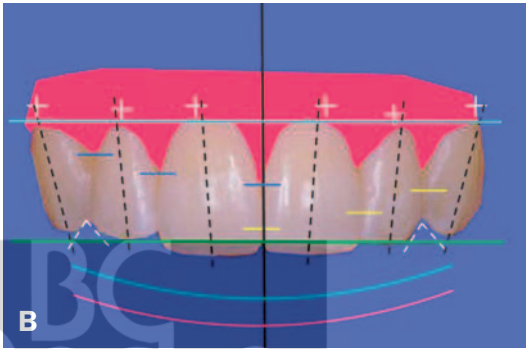
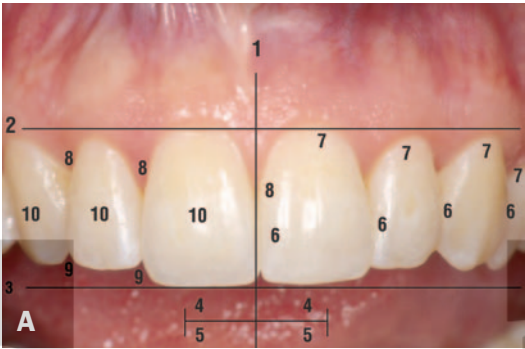


FIGURE 14-26. A and B, The dentogingival elements are listed and outlined. 1, Dental midline. 2, Gingival line. 3, Occlusal line. 4, Incisal edge curvature. 5, Lip curvature. 6, Contact points. 7, Gingival contour. 8, Gingival embrasures. 9, Incisal embrasures. 10, Axial inclination.

1. *Dental Midline*. The dental midline is the anchor by which we establish anterior radiating symmetry, harmony, balance, and proportion. It is the fulcrum or central point, producing mirror images between the right and left sides (Ahmad, 1998), as opposed to the facial midline, which, ideally, produces identical images.

The dentogingival elements (teeth and gingival tissues) approximating the midline have the greatest importance and impact. They possess greater symmetry and less variation than the elements farther from the midline (Chiche and Pinault, 1994); therefore, correct positioning is paramount (Figures 14-28 and 14-29).

The dental midline and contact point should be perpendicular to the incisor edges and parallel to the long axis of the tooth philtrum of the lip (Moskowitz and Nayyar, 1995; Cranham, 1999; Spear, 1999) and facial midline. The location of the central incisors is best determined by the following:

1. The philtrum of the lip or cupid’s bow, which references the facial midline (Spear, 1999)

2. The interdental papilla between the central incisors, which determines the true dental midline (Kokish, 1999)
3. The incisive papilla, which is a stable reference point for placement of the central incisors with and without the presence of teeth (Ortman and Tsao, 1979; Shiffman, 1984)
4. The facial and dental midlines, which are coincident when the interdental papilla and philtrum of the lip line up (Spear, 1999) (Figure 14-30). When no teeth are present, the incisive papilla may be substituted for the interdental papilla (Shiffman, 1984).

This is in agreement with Miller and colleagues (1979), who stated that if no teeth are present or the midline has been seriously disrupted, the restoring dentist should position the teeth in accordance with the facial midline and philtrum of the lip irrespective of the mandibular midline. In case of facial asymmetry, the dental and facial midlines may not be parallel or correspond to each other (Spear, 1999).

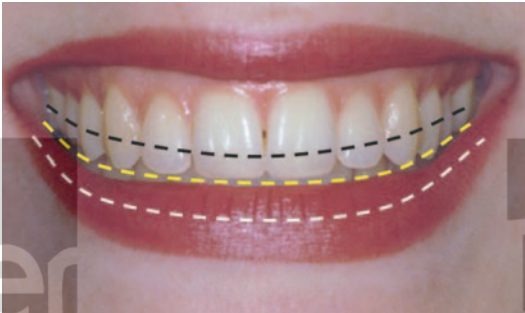


FIGURE 14-27. Dentofacial relationships. The dentogingival elements must always be parallel to the interpupillary line and at right angles to the facial midline.

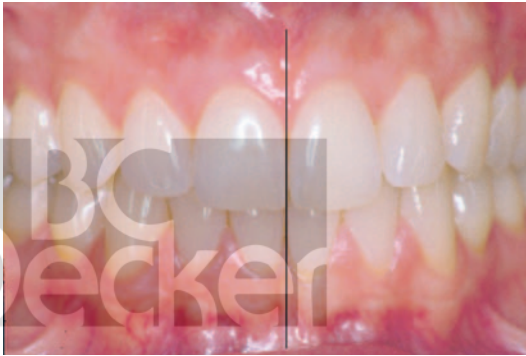


FIGURE 14-28. The dental midline.



FIGURE 14-29. Dental midline relationship. Dental midline perpendicular to the occlusal plane.

Remember that although the dental midline generally corresponds to the facial midline, it does not correspond reliably to the mandibular midline (Figure 14-31).

Kokich (1999), in his study of visual perceptions between groups of dentists, orthodontics, and lay people, found that the dental midline required a facial and dental midline discrepancy of ≥ 4 mm before it was considered unesthetic. Yet it took only 2 mm of vertical contact angulation before it was recognized as unesthetic. The reason is that parallel lines are cohesive, which allows for greater variances, whereas divergent lines are segregative and less tolerated (Figure 14-32).

2. Gingival Line. The gingival line is a line drawn from the cervical area of the right and left cuspids and should run parallel to the occlusal and commissural lines. Ideally, the central incisors and cuspids touch this line, and the lateral incisors are approximately 1 mm above this.



FIGURE 14-30. Position of the central incisors. The position of the central incisors is best determined by (A) the facial midline; (B) the philtrum of the lip; and (C) the interdental papilla.



FIGURE 14-31. Coincidence of maxillary and mandibular midlines. The maxillary and mandibular midlines are the same only 30% of the time.

The bicuspid and molars assume a more coronal position posteriorly (Frush and Fisher, 1958) (Figure 14-33).

Ahmad (1998) referred to this line as the *gingival aesthetic line* (GAL). The ideal GAL is a line at the gingival level from the cuspid to the central incisor that intersects the dental midline at an angle $> 45^\circ$ but $< 90^\circ$.

Struder and colleagues (1996) listed a number of esthetic mucogingival obstacles for prosthetic rehabilitation (Figure 14-34):

- Loss of papilla
- Localized alveolar ridge defect
- Buccal root recession
- Gingival asymmetry
- “Gummy” smile
- Gingival tattoo
- Lack of keratinized gingiva
- Unesthetic gingival texture
- High unsightly frenum

3. Occlusal Line. The occlusal line corresponds to a line drawn through the incisor edges of the canine teeth. It should be parallel to the commissure and interpapillary lines. Asymmetry or canting of the maxilla may represent skeletal or developmental problems (Figure 14-35).

4. Incisal Edge Curvature. Incisal edge curvature should follow the convexity of the lower lip. Owing to attrition, the curvature or convexity is inversely proportional to age, resulting in a broader, flatter smile with less parallelism to the lower lip. This shortening of the teeth reduces tooth exposure at both the rest and smiling positions (Figure 14-36).

Incisal edge position is the single most important factor in dental esthetics (Chiche and Pinault, 1994). This position and tooth length are determined visually and phonetically by the following:



FIGURE 14-32. Visual perception of midline changes. A, Normal. B, Horizontal shift. C, Vertical or angled shift. Note that the horizontal shift is not nearly as stressful or displeasing as the angled shift in the midline.

- Horizontal position, which is defined by the (see Figure 14-30):
 - a. Dental midline
 - b. Interdental and incisive papilla
 - c. Philtrum of the lip (facial midline)
- Vertical position, which is determined by
 - a. Static (rest) and dynamic (smiling) and strained lip positions
 - b. Consonant sounds of F and V
 - c. Lateral profile
 - d. Lip position and lip support



FIGURE 14-33. Gingival line.



FIGURE 14-34. Mucogingival obstacles to prosthetic rehabilitation. Mucogingival factors that prevent satisfactory prosthetic rehabilitation. A, Loss of papilla. B, Localized alveolar ridge defect. C, Buccal recession. D, Gingival symmetry. E, Gummy smile. F, Gingival tattoo. G, Inadequate keratinized gingiva. H, Unesthetic gingival texture. I, Unsightly frenulum.

5. Lower Lip Curvature. Lower lip curvature is assessed during dynamic positioning or smiling and serves as the general guide for the curvature or convexity of the incisor edges and contact points (Figure 14-37).

6. Contact Points. The contour of the contact points should follow the convexity of the incisor edges and lip curvature. The contacts are highest on the central incisors and move apically as we progress distally, thus opening or widening the incisor embrasures (Figure 14-38).

A contact point is represented by small areas of tooth contact (about 2×2 mm) between abutting teeth. Connectors are broad areas of close approximation between the anterior teeth that help determine the size of the gingival embrasure (Morely and Eubank, 2000) (Figure 14-39).

7. Gingival Zenith or Height of Gingival Contour. The apex of the gingival height of contour on the anterior teeth is as follows (Figure 14-40):

- Central: distal third
- Lateral: central
- Cuspid: distal third
- Bicuspid: central

Note: There is a general parallelism of the contact points, incisal edges, and lower lip curvature (Figure 14-41).

8. Gingival Embrasure. The gingival embrasure produces harmony in the dental composition. The size, shape, and position of the gingival embrasure are determined by the position of the contact point, shape of the teeth, and underlying osseous topography (see Chapter 18,

Crown Lengthening). In a healthy patient, the gingival embrasure is filled with tissue that is scalloped more anteriorly and flattens out in the molar areas (Figure 14-42). The degree of gingival scallop and width of gingival embrasure are dependent on tooth biotype (Weisgold, 1977) (Figure 14-43).

Note: See Chapter 17, “Periodontal Biotypes,” for a more detailed analysis.



FIGURE 14-35. Occlusal line.

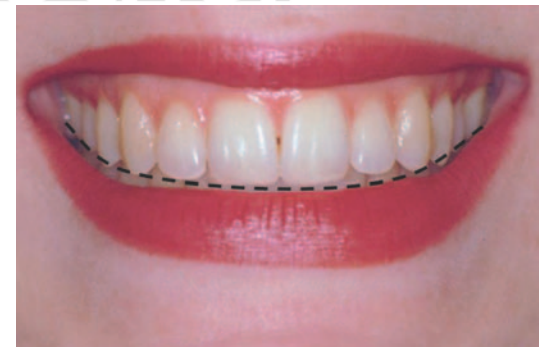


FIGURE 14-36. Incisal edge curvature.

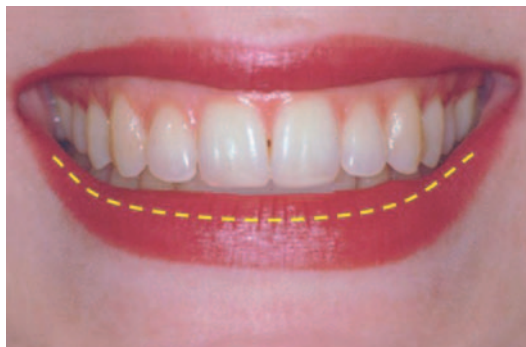


FIGURE 14-37. Lower lip curvature.

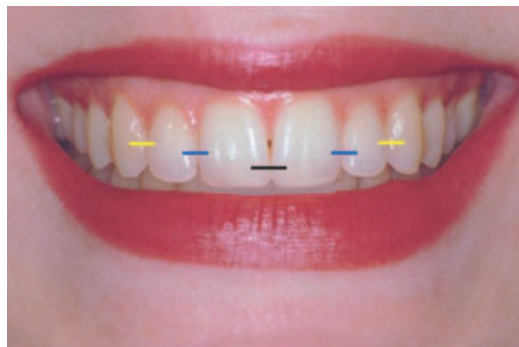


FIGURE 14-38. Contact points.



FIGURE 14-39. Contact connectors.



FIGURE 14-40. Gingival zenith or height of contour.



FIGURE 14-41. Parallel relationships between contact points, incisal edges, and lower lip curvature.



FIGURE 14-42. Gingival embrasures. The height of the gingival embrasures (yellow) varies with the height of the contact points (black).

9. Incisal Embrasure. The incisal embrasure is the sign of an unworn youthful dentition. The embrasures increase in size as they move away from the central incisors owing to more apical contact placement. Occlusal wear reduces the embrasure and broadens the contour (Moskowitz and Nayyar, 1995; Morely and Eubank, 2001) (Figures 14-44 and 14-45).

10. Axial Inclination. The teeth are either straight or inclined in a medial direction. This is considered more pleasing than a distal inclination. Convergent or parallel lines tend to be more unifying and harmonious than divergent or distal inclined lines (Figures 14-46 and 14-47).

11. Buccal Corridor. The buccal corridor is the negative space that is present between the buccal surface of the posterior teeth and the corner of the lips when the patient smiles (Frush and Fisher, 1958). It begins at the cuspid, is variable in size, and serves to prevent a toothy or molar-to-molar smile (Figure 14-48).

IV. Dental Composition

A. Tooth Morphology

1. **CENTRAL INCISORS.** The central incisors are the most dominant teeth anteriorly and must be kept symmetric, within reasonable limits. They must be of sufficient size to dominate the smile (Frush and Fisher, 1958; Lombard, 1973). Small variations of 0.2 to 0.4 mm are acceptable (Figure 14-49).

The central incisors determine:

- Midline
- Phonetic speaking line (*F* and *V*)
- Labial positioning of the teeth
- Gender and personality (according to their shape)
- Lip support
 - a. Upper lip: cervical two-thirds
 - b. Lower lip: incisal edge



FIGURE 14-44. Incisal embrasures.



FIGURE 14-46. Axial inclination.



FIGURE 14-43. Biotype. A, Scalloped biotype. B, Flat biotype.

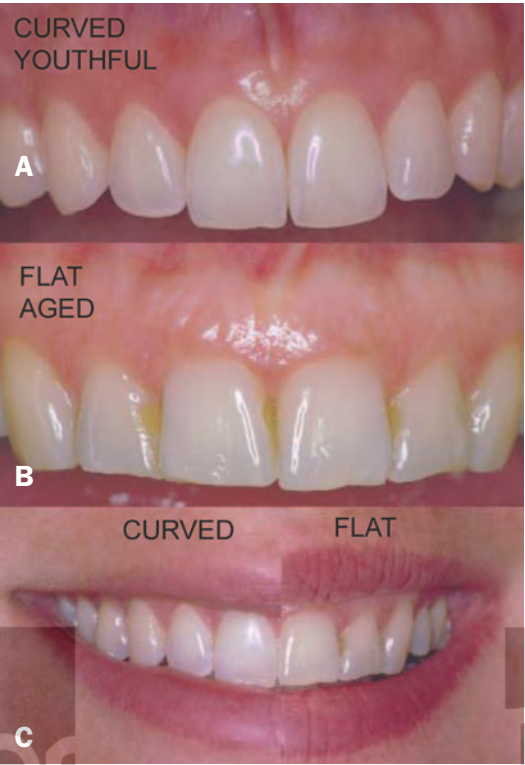


FIGURE 14-45. Incisal embrasure, young versus old. A, Young person with prominent incisal embrasures. B, Older person with loss of incisal embrasure. C, Youthful versus older smile. Note significance differences.

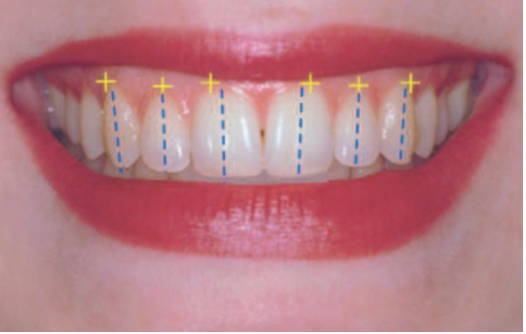


FIGURE 14-47. Axial inclination versus height of gingival contour. It is important to note that they are not coincidental.

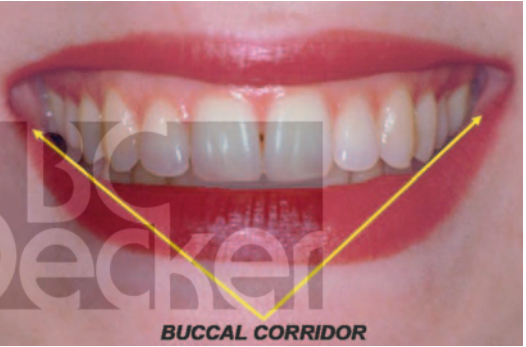


FIGURE 14-48. Buccal corridor.

Dominance can be increased or decreased by varying tooth size and color (Lumbard, 1973).

The characteristics of central incisors are:

- Symmetrical within limits (37% – 0.2 mm)
- Determines
 - Dental midline
 - Speaking line
 - Smile line
 - Lip support
- Personality
 - Long and rounded – Feminine
 - Square – Masculine

2. LATERAL INCISORS. The lateral incisor is often referred to as the *personality tooth* because its shape determines sex. Rounding of the incisal edge creates a feminine effect, and squaring of the incisor edge creates a masculine effect (Frush and Fisher, 1958).

The lateral incisor has the greatest variation in width (3.98 mm) and general asymmetry. This results in radiating symmetry, with variation in size, shape, position, axis, length, and gingival display. Therefore, surgery is indicated only if the gingival asymmetry is displeasing (Chiche and Pinault, 1994) (Figure 14-50).

The characteristics of lateral incisors are:

- Subordinate to central incisor
 - Bilateral asymmetry is common
 - Gingival margin variations
 - Personality
 - Rounded – Feminine
 - Square – Masculine
3. CUSPIDS. The cuspids form the corner of the arch, control the effective width of the smile, and occlude part of the buccal corridor. Their uneven cuspal wear results in a radiating asymmetry of the incisor embrasures (Figure 14-51).

Note: In Figures 14-52 to 14-54, we can see the tooth characteristics and morphologic changes in the youthful and the aged dentition.

The characteristics of cuspids are:

- Crown length similar
- Wear patterns differ
- Rotated to display mesial surface
- Cervical prominence not tip
- Variations in vertical alignment



FIGURE 14-49. Central incisors.



FIGURE 14-50. Lateral incisors.

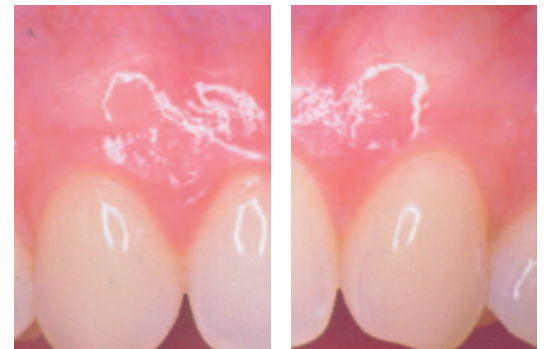


FIGURE 14-51. Cuspids.



FIGURE 14-52. Characteristics of a youthful smile.

B. Tooth Proportion. Dental composition is based not only on individual tooth size and shape (Figure 14-55) but also on its interrelationship with the other teeth. Furthermore, because the lip acts like a picture frame to bind the dental elements into a separate organized entity, the individual teeth become secondary to the group in which they reside—the primacy of the whole (Lombard, 1973) (Figure 14-56).

Tooth morphology is determined by heredity and is independent of other factors. There is no objective evidence that tooth size should be based on facial form, sex, race, or facial size (Frush and Fisher, 1958). Nevertheless, general guidelines are required if esthetic form is to be achieved.

Chiché and Pinault (1994) outlined a number of factors for determining tooth size:

- Tooth proportion
- Proportion by anatomic characteristics
- Proportion by facial form

1. ANATOMICAL TOOTH PROPORTION. Tooth proportion or the width-to-length ratio is determined by dividing the tooth width by the tooth length. The ideal tooth ratio size has been determined to be 0.75 to 0.80 mm. Too great a ratio



FIGURE 14-54. Composite picture of youthful, aged, and side-by-side comparison of youthful and aged smiles.

(> 0.8 mm) and the tooth will appear too short, and too low a ratio (< 0.65 mm) and the tooth will appear to be too narrow (Lombard, 1973) (Figure 14-57). The following is the repeated ratio formula:

$$\frac{\text{Width of tooth}}{\text{Length of tooth}} = \text{Ideal ratio is 0.75 to 0.80 mm}$$

Chiché and Pinault (1994) noted that the width of the central incisors varies from 8.37 to 9.3 mm and the length varies from 10.4 to 11.2 mm. Therefore, the average width-to-length ratio varies from 0.74 to 0.89 mm, which is consistent with Wheeler’s carving ratio, 8.0 mm (8.5/10.5 mm), and the ratios of Woelfel, 0.76 mm (8.6/11.2 mm), Bjorndal and colleagues, 0.8 mm (9.0/11.2 mm), and Shellingburg, 0.8 mm (8.5/10.4 mm) (Wheeler 1966, Bjornaul 1974, Wuelfel 1990).

2. GOLDEN PROPORTION. A pleasing smile should have the maxillary central incisors dominate the smile. The golden proportion is but one method of establishing both the dominance of the maxillary incisors and unity and proportion for all of the anterior teeth. The golden proportion has also been known as the golden section, golden



FIGURE 14-53. Characteristics of an older person's smile.

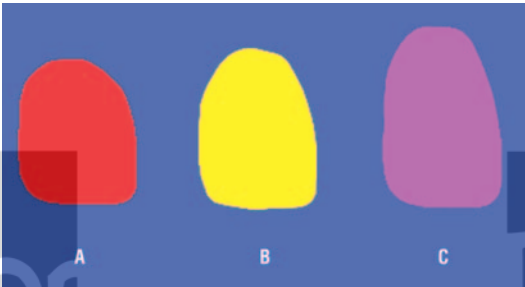


FIGURE 14-55. Tooth proportion. All three teeth are the same width but have different lengths. Note how visual perception changes as tooth ratio changes.

mean, golden ratio, perfect division, and, simply, phi (Phillips, 1999). The golden proportion, rectangle, or phi occurs in nature (sunflower, Nautilus shell), in the human body (finger bones, smile), in mathematics (Fibonacci series of numbers), and in art (Greek Parthenon) (Figure 14-58).

The golden proportion is represented by the ratio of 1:1.6 and by the mathematical formula

$$S/L = L / (S + L) = 2/1 + \sqrt{5} = 0.618$$

Linear Geometric Arithmetic

The uniqueness of the golden proportion is that the same mathematical result is achieved whether calculated as a linear, geometric, or arithmetic progression. Some say this uniqueness makes this ratio esthetically pleasing. Levin (1978) developed a series of anterior “golden proportional grids” that were to be used by restorative dentists. They are based on the concept that



FIGURE 14-56. Primacy of the whole. Note how the (A) individual teeth are not nearly as important when grouped (B) as a unit and framed by the lips (C).

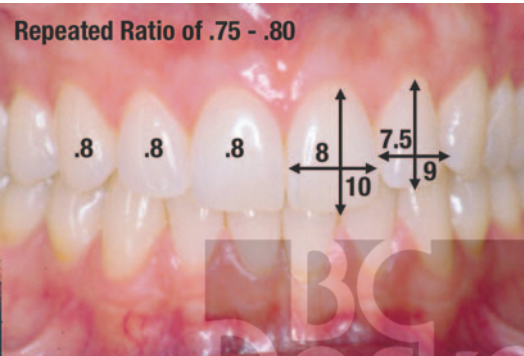


FIGURE 14-57. Repeated ratio in millimeters.

the visible widths of the incisors are in golden proportion to each other when viewed from the front. Furthermore, he interrelated the golden proportion between the facial and dental elements in such a manner as to facilitate prosthetic reconstruction.

Note: The golden proportion should be applied only after the following have been determined (Javaheri and Shahnavez, 2002):

- a. Incisal edge position
- b. Central incisor length
- c. Incisal edge plane
- d. Gingival plane

This is different from the clinical width of the tooth. The golden proportion for the anterior teeth is as follows:
Central incisor = 1.68
Lateral incisor = 1
Cuspid = .68

It is the same for half of the sextet as it is for all six teeth.

Note: The value of the golden proportion is as a diagnostic tool for smile evaluation and veneer fabrication (Javaheri and Shahnavez, 2002).

3. FACIAL FORM. Studies to show the interrelationship between facial form and tooth morphology have proven to be unreliable (Lumbard, 1973). Yet, in spite of that, Chiché and Pinault (1994) noted a number of theories that have been developed and are still advocated today:

- 1. Biometric ratio (Berry, 1905): The inverted maxillary tooth form approximates the facial outline form.
- 2. Bizygomatic width (House and colleagues, 1929): Tooth size is related to one-sixteenth of the zygomatic width.
- 3. Geometric theory (Williams, 1914): Facial shape and tooth form should coincide.
- 4. Dentinogenic theory (Frush and Fisher, 1973): Tooth size is determined by sex, age, and personality or SAP.

Summary

It may be stated that a pleasing smile can be achieved by using a constant ratio of 0.75 to 0.80 mm between the anterior teeth, providing for the dominance of the maxillary central incisors, with the diversity of individual elements providing for radiating symmetry, parallelism, and symmetry not only between the dentogingival elements but also between the facial and dentofacial structures.



FIGURE 14-58. Golden proportion. A, Normal smile. B, Mathematical formula for the golden proportion. C, Ratio applied to all six teeth. D, Ratio applied to half of a sextet. E, Repeated ratio versus the golden proportion

The Ideal Smile

The ideal smile possesses the following characteristics:

1. Parallelism between the facial and dentofacial elements

a. Interpupillary line

b. Incisal line
- c. Gingival line

d. Commissural line
2. Coincidence of the dental and facial midlines

3. Parallelism of the incisal and lower lip curvatures

4. Incisal edges perpendicular to the dental midline
5. Tooth exposure of 2 to 4 mm with the lips at rest

6. Gingival display of 1 to 3 mm during smiling

7. Filled gingival embrasures

8. Well-defined incisal embrasures

9. Bilateral buccal corridor



Differential Diagnosis of Anterior Tooth Exposure

Kinetics of Anterior Tooth Display

The kinetics of anterior tooth display is based on the dynamic equilibrium that exists between the static and dynamic states of lip position (Figure 15-1). The restorative dentist, when viewing a patient with either inadequacies of tooth length and/or excess gingival exposure, must develop a paradigm for analyzing these esthetic deficiencies. That paradigm must be one that is able to determine if nonsurgical, orthodontic surgical, or some combination of therapies is required to correct these inadequacies. It is far easier and less invasive to correct the situation prosthetically or orthodontically than surgically; therefore, the proper diagnosis is paramount. Spear and colleagues (2006) noted that, historically, treatment began with the biologic and functional basis and often resulted in compromised esthetic results. As a consequence, they believe that when the esthetic requirements are important, they must precede the biologic and functional requirements.

Note: The previous sections have extensively discussed the key individual esthetic dentofacial, dentogingival, and dental elements necessary for achieving esthetic beauty. We now use these basic elements to develop diagnostic and treatment models.

Differential Diagnosis

Incisal Edge Position

The incisal position of the maxillary central incisor, because it serves to determine the proper tooth proportion and gingival level, is the foundation on which the smile is built (Cliché and Pinault, 1994; Morley and Eubank, 2001; Spear and colleagues, 2006). This is consistent with our previously stated concepts that maxillary incisor dominance and a pleasing width-to-length ratio (0.70–0.80) are the two principal determinants for establishing anterior esthetic harmony, balance, proportion, and radiating symmetry (Ahmad, 1998; Cranham, 1999) (Figure 15-2).

Tooth-Lip Interrelationship

Static or Rest Position of the Lips. In the static or rest position, the lips are naturally parted and the teeth are out of occlusion. This has also been referred to as the *M position* (Moskowitz and Nayyor, 1995; Morely and Eubank, 2001) because the true rest position is facilitated by having the patient repeat the letter *M*. Tooth exposure is then carefully evaluated and compared with the expected averages for age, sex, and lip length (Table 15-1).

Dynamic or Smiling Lip Position. It cannot be stressed enough that smiling is both dynamic and variable and either spontaneous or acquired. The dynamic position is determined by the degree of contraction of the facial muscles, the size and shape of the lips, the size and shape of the dental elements, and the skeletal makeup (Ahmad, 1998) (Figure 15-3).

The acquired or learned smile is a conscious or unconscious effort on the patient's part to

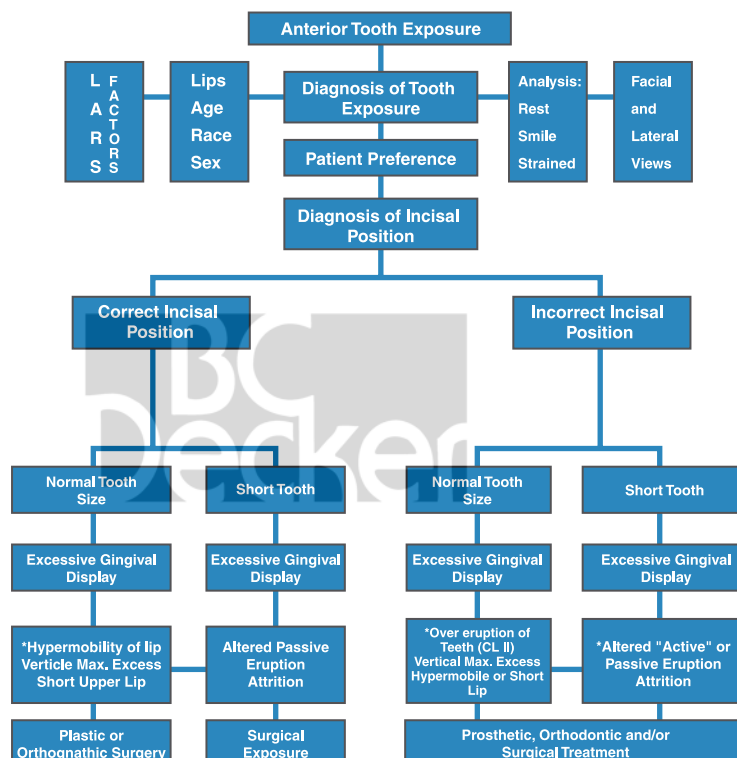


FIGURE 15-1.



FIGURE 15-2. Incisal position and dominance of maxillary central incisors. A to D, Facial, dentofacial, dentogingival, and dental views showing how maxillary incisal position, dominance, and proportion dominate a smile.

Table 15-1 Average Maxillary Incisor Display (mm) with Lips at Rest					
Sex		Lip Length		Age	
Men	Women	Short	Long	Young	Middle-aged
1.91	3.40	3.65	0.59	3.37	1.26
Adapted from Vig and Bruno (1978) and Cliché and Pinault (1994).					

mask off something he or she perceives to be negative. Whether it is the hand in front of the mouth or the narrow, tight-lipped smile that decreases tooth exposure, it is incumbent on the restorative dentist to overcome these limitations. If not, then the rehabilitation will be esthetically unacceptable (Figure 15-4).

To help overcome some of these acquired limitations, Morely and Eubank (2001) recommended that the patient repeat the letter *E*, which they refer to as the *E position*. The smile, once obtained, must be analyzed in both its natural and strained positions both facially and laterally. This permits maximum visualization of all of the dentogingival elements. Everything revealed is

then considered part of the esthetic zone and is properly evaluated.

The dynamic lip position is determined both facially and laterally and will permit analysis of three key factors:

1. Smile line limits
 - a. Vertical limit: The degree of gingival exposure ideally should be only 1 to 3 mm above the cervical area of the tooth (Kokich, 1999).
 - b. Horizontal limit: This is the maximum posterior tooth exposure when the patient is smiling fully both normally and strained. It determines the posterior

extent of both the surgery and the prosthetic requirements (Figure 15-5).

2. Incisal line/lip line convexity: The incisal line should be parallel to and follow the curvature of the lower lip.
 - a. Loss of convexity is indicative of attrition.
 - b. Coverage by the lower lip may indicate extrusion (15-6).
3. Phonetics: Incisal edge position is not only determined visually but also phonetically when pronouncing certain consonants.
 - a. F: The incisors should approximate or lightly touch the vermillion boarder of the lips.
 - b. V: The incisors are positioned slightly behind the vermillion boarder of the lips.
 - c. S: Pound (1977) referred to this as the vertical dimension of speech or the anterior speaking space. In this position, no teeth are in contact, and there is ≥ 1.5 mm of space between the incisal edges.

Note: On restored teeth, inadequate tooth preparation results in overcontouring of the incisal edge (thickness > 2.5 mm), resulting in apparently more labial placement of the teeth (Cliché and Pinault, 1994). This may adversely effect the F and V incisal edge positions and upper lip position (Figure 15-7).

4. Spear and colleagues (2006) cited three additional key factors for determining incisal position by visualization:
 1. Dental midline
 2. Mesiolateral inclination
 3. Labiolingual inclination



FIGURE 15-3. Static and dynamic lip positions, facial and lateral views. A, Static. B, Smile. C, Strained smile.



FIGURE 15-4. Acquired or learned versus actual smile. A, Learned smile. Note the tight lips. B, Actual smile. Note the significant change in the vertical limit of tooth and tissue exposure.



FIGURE 15-5. Smile limit determinations before treatment dictate the treatment and final results. *A* and *A'*, Vertical limits before and after treatment. *B* and *B'*, Horizontal or lateral limits before and after treatment. *C*, A prosthetic or surgical stent was fabricated to check the requirements prior to treatment (see Chapter 19, "Altered Passive Eruption", Fig. 19-10 for the stent fabrication technique).

Tooth Size Determination

Anatomic Tooth Size Determination. The maxillary central incisor is measured in both width and length and should have the following general anatomic size:

1. Average width of 8.3 to 9.3 mm
2. Average length of 10.4 to 11.2 mm
3. Average width-to-length ratio of 0.75 to 8.0

The clinical and anatomic crowns (exposure of the cemento-enamel junction [CEJ]) should also be coincident. If not, then probing to the CEJ will reveal the actual tooth size from which a correct width-to-length ratio can be established and acceptability determined. An inability to properly probe the CEJ may indicate a high bone level with a coronally positioned dentogin-

gival complex indicative of altered passive eruption (Kois, 1996).

Tooth Size: Occlusal Plane Analysis. Incisal-occlusal anterior-posterior plane (IOP) discrepancies, tooth size, and gingival display are important factors for differentiation between overeruption of the premaxilla, attrition, and altered passive eruption:

Robins (1999) noted that excessive gingival display is a descriptive term rather than a diagnosis and requires a differential diagnosis (Figure 15-8).

Analysis for Treatment

The interrelationship between incisal tooth position and tooth size at the rest and dynamic lip positions rest and smile determines the suitability-



FIGURE 15-6. Incisal lip convexity. *A* and *B*, Normal and worn (attrition) dentitions. Note the loss of incisal lip parallelism owing to attrition. *C* and *D*, Note the increase in incisal convexity of the teeth with extrusion of the premaxilla, creating a deep overbite.

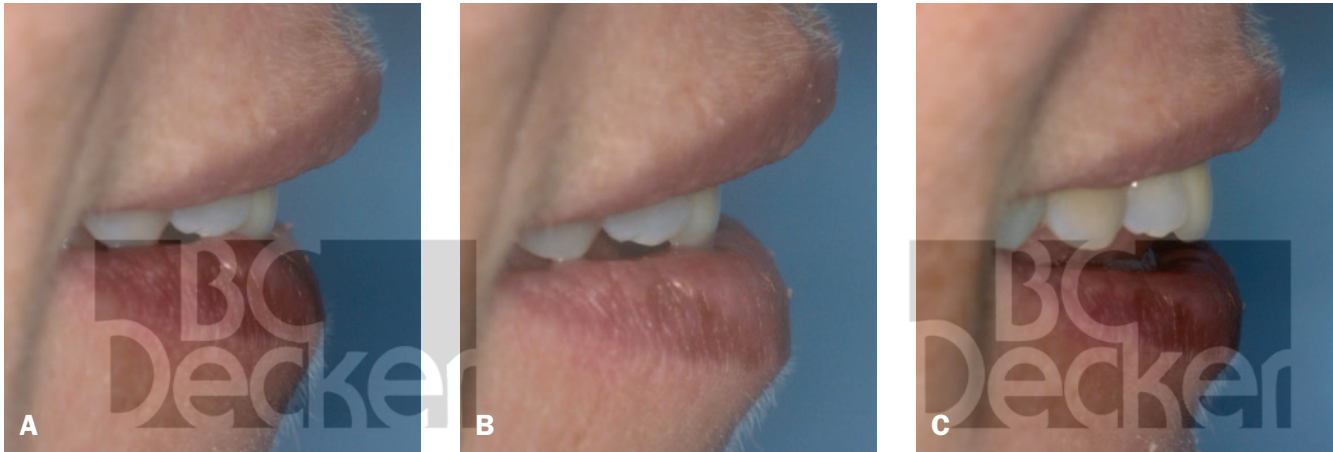


FIGURE 15-7. Phonetics and teeth-lip relationship. *A*, *F*, incisors anterior to the vermillion border of the lip. *B*, *V*, incisors lingual to the vermillion border of the lip. *C*, *S*, incisors slightly open.



FIGURE 15-8. Overeruption versus attrition versus altered passive eruption: gummy smile analysis. *A* and *A'*, Overeruption of teeth: excessive tooth exposure at rest, incisal convexity exaggerated, incisal-occlusal anterior-posterior plane (IOP) discrepancy. *B* and *B'*, Attrition: flat incisal convexity, no IOP discrepancy. *C* and *C'*, Altered passive eruption. Incisal convexity normal; no IOP discrepancy.

ty for treating individual cases. The gingiva should not be used as a reference point because it moves (Spear, 1999).

Treatable Cases. Anytime there is a significant discrepancy between incisal position, IOP, tooth size at the rest and/or smiling positions, and gingival display, then treatment is possible. Such conditions are

1. Altered passive eruption
2. Overeruption of the premaxilla (deep overbite) (IOP discrepancies)
3. Attrition
4. Altered active eruption
5. Combinations

Once it has been determined that lengthening or alterations in the gingival levels are required, the location is determined

1. Incisally
2. Gingivally
3. By a combination (Figure 15-9)

It is incumbent on the dentist to select the proper treatment modality:

1. Prosthetic: lengthen or shorten
2. Orthodontic: extrude (lengthen), intrude (shorten), and/or correct the position
3. Surgical: lengthen
4. Combination

Note: The restorative dentist should establish the final incisal position prior to referring and indicate if the lengthening is strictly for esthetic reasons on the facial area only or for prosthetic reasons requiring 360° of treatment (Levine and McGuire, 1997). It is important to note that in total prosthetic rehabilitation cases, the posterior plane of occlusion and the patient's vertical dimension must be established prior to the anterior incisal tooth position (Keough, 2003).

Nontreatable Cases. If tooth exposure at rest is normal (2–4 mm), the incisal position is correct, the tooth size is within normal limits (10.4–11.2 mm), IOP (incisal occlusal plane) discrepancies are absent, and there is still an excessive display of gingival tissue, treatment is not possible by crown lengthening alone (Figure 15-10). Examples of such situations are

1. Hypermobility of the lip
2. Vertical maxillary excess
3. A short upper lip

Note: In these situations, there is also a generalized display of excessive gingival tissue both anteriorly and posteriorly. Treatment is generally possible only with a combination of orthodontic plastic and/or orthognathic surgery (Figure 15-11).

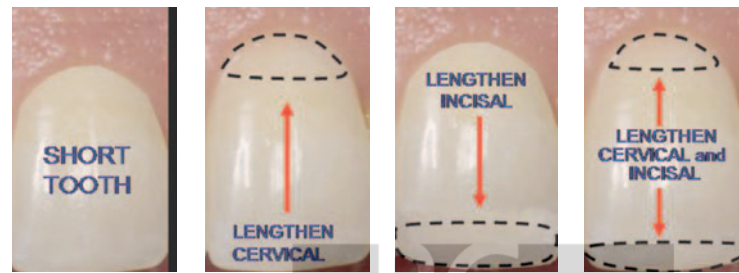


FIGURE 15-9. Determination for tooth alteration. One must determine if the tooth has to be lengthened cervically, incisally, or both prior to proceeding with treatment.



FIGURE 15-10. Treatment determinations. A, Prosthetic lengthening. B, Orthodontic intrusion/extrusion. C, Surgical lengthening. D, Combination.



FIGURE 15-11. Nontreatable cases. *A* and *A'*, Hyper-mobility: normal rest position exposure, excessive gingival display, normal tooth size. *B* and *B'*, Vertical maxillary excess: normal tooth size at rest, normal tooth size, excessive gingival display. *C* and *C'*, Short upper lip. Excessive tooth exposure at rest, normal tooth size, excessive gingival display.

Table 15-2 Diagnostic Determinants			
Teeth	Overeruption*	Attrition	Altered Passive Eruption
Gingival display	Excessive	Excessive	Excessive
CEJ exposed	Yes	Yes	No
Tooth size	Normal	Short	Short
Incisal position	Incorrect	Correct	Correct
Premaxilla eruption	Yes	Yes	No
IOP discrepancy	Discrepancy	Normal	Normal
Incisal convexity	Curved	Flat	Curved
Deep overbite	Yes	No	No

CEJ = cementoenamel junction; IOP = incisal-occlusal anterior-posterior plane.
*Overeruption may result in an anterior convex gingival and incisal contour and the teeth being covered by the lower lip.

Biologic Width

Restoration of fractured (traumatized), severely decayed, partially erupted (delayed passive eruption), worn, or poorly restored teeth is often difficult, if not impossible, for the dentist without surgical or orthodontic intervention. Surgical exposure or crown lengthening of these teeth is necessary to provide adequate tooth structure for restoration or esthetic enhancement, thus adhering to base biologic principles by preventing impingement on the periodontal attachment apparatus or biologic width (Figure 16-1).

Biologic width is the term applied to the dimensional width of the dentogingival junction (epithelial attachment and underlying connective tissue). It was first described by Sicher in 1959. Gargiulo and colleagues (1961) studied the anatomy of the dentogingival junction and quantified the average as a constant 2.04 mm (the epithelial attachment is 0.97 mm, and connective tissue is 1.07 mm) with a sulcus depth of 0.69 mm (Table 16-1). The dentogingival junction was, in fact, variable depending on the loca-

tion or phase (I–IV) of the dentogingival junction attachment (Table 16-2).

Note: The actual biologic width (dentogingival junction) in adults is 1.80 mm (III) and 1.77 mm (IV), which is less than the universally accepted 2.04 mm.

Nevins and Skurow (1984) defined biologic width as the sum of the combined supracrestal fibers, the junctional epithelium, and the sulcus. This was over 3 mm when measured from the crest of bone.

Vacek and colleagues (1994) histologically studied the biologic widths of individual tooth grouping (anterior, bicuspids, molars) and its relationship to subgingival restorations. They found that the biologic width increased antero-posteriorly (1.75 to 2.08 mm) and that 15% of the restorations that impinged in the biologic width had a biologic width of less than 2.04 mm. They questioned the minimum biologic width required for health. It is important for the clinician to rec-

ognize the wide range and viability of the different components comprising the biologic width (sulcus, epithelial attachment, connective tissue).

Note: Because of the anteroposterior increase in biologic width, the clinician may want to increase the amount of tooth structure exposed when performing crown-lengthening procedures.

Interproximal Dentogingival Complex

Interproximally, although the biologic width is similar to that of the facial surface (Gargiulo and colleagues, 1961; Vacek and colleagues, 1994), the total dentogingival complexes are not. Kois (1994) and Spear (1999) pointed out that the dentogingival complex is 3.0 mm facially and 4.5 to 5.5 mm interproximally. They noted that the height of the interdental papilla can only be explained partially by the increased scalloping of the bone. Becker and colleagues (1997) defined variations of gingival scallop (flat, scalloped, and pronounced scal-

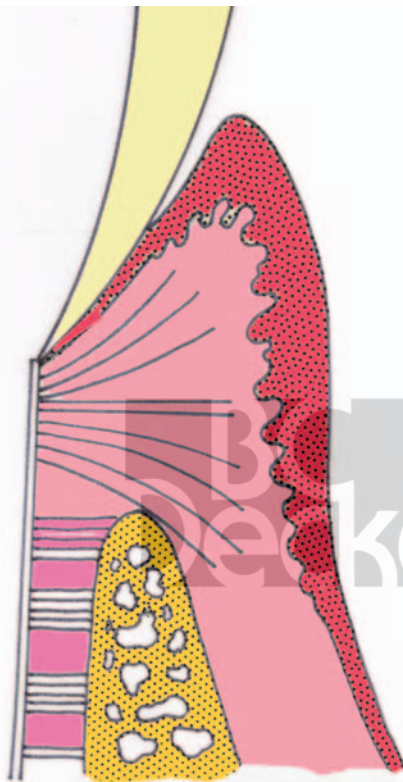


FIGURE 16-1. Plate picture of biologic width.

Table 16–1 Dentogingival Junction

Total Attachment (mm)					
	Length of Epithelial Attachment (B)	Connective Tissue Depth (F)	Biologic Width B + F	Sulcus Depth (A) B + F + A	Total Attachment
Composite average of all phases	0.97	1.07	2.04	.69	2.73
Phase and environment					
III Attachment on cementum (at CEJ)	0.74	1.06	1.80	.61	2.41
IV Attachment on cementum (below CEJ)	0.71	1.06	1.77	1.77	3.54
CEJ = cementoenamel junction.					

Table 16-2 Dentogingival Junction

Average Magnitude (mm) for Anterior, Premolar, and Molar Teeth						
Length of Epithelial Attachment (B)	Connective Tissue Depth (F)	Biologic Average B + F	Width Range (A)	Sulcus Average B + F + A	Depth Range	Total Attachment
1.15	0.79	1.94	0.79–3.64	1.34	0.42–4.44	3.28

lop) by the distance in gingival tissue height between the facial and interproximal areas (2.1, 2.8, and 4.1 mm). The average height difference is 3.0 to 3.5 mm (Wheeler, 1961).

Spear suggested that the additional 1.5 to 2.5 mm of interproximal gingival tissue height requires the presence of adjacent teeth for maintenance of interproximal gingival volume. Without the presence of adjacent teeth, the interproximal tissue would flatten out, assuming a normal 3.0 mm biologic width with the underlying bone scallop, and esthetics would be compromised. These findings are consistent with those of Tarnow and colleagues (1992), who found that for the gingival tissue to assume complete filling of the interdental space, the distance from the contact point to the osseous crest should not exceed 5 to 5.5 mm. Greater distances result in significant loss of gingival height (Table 16-3 and Figure 16-2). This was confirmed by Cho et al (2006) who also found that as the interproximal distance between the teeth increased the number of papilla that filled the interproximal space also decreased.

Van der Velon (1982), using interproximal denudation, showed that the interproximal tissue rebounded or regenerated 4.33 mm 3 years later. This is consistent with Nyman’s (1977) and Rusling’s (1976) findings of 3.5 and 5.1 mm, respectively, of tissue rebound after 2 years. Clinical experience has led some clinicians to recommend waiting at least 6 months (Maynard and Daniel, 1977; Rosenberg and colleagues, 1999;

Lanning and colleagues, 2003; Deas and colleagues, 2004) to 3 years (Kois, 1994) to permit full maturation and tissue rebound to occur.

Note: The relationship between the contact point, osseous crest, and total dentogingival complex is one of interdependence that both the surgeon and the clinician must take note of, especially in high-smile line cases.

Table 16-3 Presence or Absence of Papilla								
	Distance in mm from Contact Point to Crest to Bone (N)							
	3	4	5	6	7	8	9	10
	(2)	(11)	(73)	(112)	(63)	(21)	(4)	(2)
Papilla present	2	11	72	63	17	2	1	0
Papilla not present	0	0	1	49	46	19	3	2
% present	100	100	98	56	27	10	25	0
% not present	0	0	2	44	73	90	75	100
Adapted from Tarnow and colleagues (1992).								



FIGURE 16-2. Anatomic factors in determining facial and interproximal biologic width differences. A, Gingival differences between the height of gingival tissue over the bone facially and interproximally. B, Facial and interproximal bone compared showing 1 mm of greater scalloped bone height interproximally. C, Tissue bone interrelationship showing 2 mm of greater unsupported tissue height interproximally.

Periodontal Biotypes

The periodontium has been described as having two basic forms: thin and scalloped or thick and flat (Oschenbein and Ross, 1973; Weisgold, 1977; Jensen and Weisgold, 1995). Olsson and Lindhe (1991) referred to these as *periodontal biotypes*.

Oschenbein and Ross (1969, 1973) considered the two different tissue types to be genotypes with an inherent tendency for the highly scalloped tissue to rebound a few months later irrespective of the underlying osseous support. Olsson and Lindhe (1991) found the thick and flat periodontal biotype to be more prevalent than the thin and scalloped form (85% to 15%).

Each biotype possesses its own characteristics, which impact on the clinical outcome. The surgeon must pay particular attention to them if a successful stable postsurgical dentogingival complex is to be achieved. The following characteristics have been assigned to each biotype (Oschenbein and Ross, 1969; Jensen and Weisgold, 1995; Seadoun and Le Gall, 1998)

Thin and scalloped (Figure 17-1A):

1. Delicate thin periodontium
2. Highly scalloped gingival tissue
3. Usually slight gingival recession
4. Highly scalloped osseous contours
5. Underlying dehiscences and/or fenestrations
6. Minimum zones of keratinized gingiva
7. Small incisal contact areas
8. Insult results in recession
9. Triangular anatomic crowns
10. Subtle diminutive convexities in cervical third of the facial surface

The highly scalloped gingivally contoured tissue generally has a total dental gingival complex that is greater than 5 mm interproximally and therefore is the most difficult to maintain

(Tarnow and colleagues, 1992) postsurgically. Care must also be exercised during tissue retraction and placement of crown margins within the sulcus to prevent recession.

Thick (dense) and flat (Figure 17-1B)

1. Thick heavy periodontium
2. Flat gingival contour
3. Gingival margins usually coronal to the cemento enamel junction

4. Thick, flat osseous contour
5. Wide zone of keratinized gingiva
6. Broad apical contact areas
7. Square anatomic crowns
8. Insult results in pocket depth or redundant tissue
9. Bulbous convexities in cervical third of the facial surface

The stability of the osseous crest and position of the free gingival margin are directly proportional to the thickness of the bone and gingival tissue. This is in agreement with Maynard and Wilson (1979), who recommended a 5 mm zone of keratinized gingiva (3 mm of attached gingiva), and Stetler and Bissada (1987), who showed less inflammation and shrinkage when subgingival margins are placed in a thicker tissue.

Kois (2004) noted certain key bone, tissue, and biotype interrelationships that determine the stability of interdental papilla and gingival margin (Table 17-1).



FIGURE 17-1. Biotypes: Thin scalloped vs thick flat. A, Thin scalloped. B, Thick flat.

Table 17-1 Bone, Tissue, Biotype Interrelationships

Factors	Positive (Stability)	Negative (Recession)
Free gingival margin—CEJ	Coronal	Apical
Periodontium form—scallop	Low	High
Biotype	Thick	Thin
Shape—tooth	Square	Triangular
Osseous crest	High	Low

CEJ = cemento enamel junction.



Crown Lengthening

The concept of tooth lengthening was first introduced by D. W. Cohen (1962) and is presently a procedure that often employs some combination of tissue reduction or removal, osseous surgery, and/or orthodontics for tooth exposure. The amount of tooth structure exposed above the osseous crest (about 4 mm) must be enough to provide for a stable dentogingival complex and biologic width to permit proper tooth preparation and account for an adequate marginal placement, thus ensuring a good marginal seal with retention for both provisional and final restorations (Ingber and colleagues, 1977; Rosenberg and colleagues, 1980; Saadoun and colleagues, 1983; Allen, 1993; Miller and Allan, 1996; Kois, 1994, 1996, and 2004; Rosenberg and colleagues, 1999; Spear, 1999; Becker and colleagues, 1998; Lanning and colleagues, 2003).

Note: Margin location relative to the osseous crest: Biologic width interface is more important than the distance below the free gingival margin (Kois, 1994). Impingement on the zone (biologic width) may result in bone absorption, gingival recession, or gingival inflammation or hypertrophy.

Indications

1. Caries
2. Trauma or fracture
3. Altered passive eruption
4. Restorative requirements
5. Root surface perforations
6. External root resorption

Restorative Considerations

1. Esthetics
2. Function
3. Form
4. Retention
5. Marginal seal

Evaluation

Clinical Evaluation

1. Sulcus depth
2. Biologic width
3. Osseous crest
4. Pulpal involvement

5. Apical extent of fracture
6. Gingival health
7. Furcation location
8. Loss of mesial, distal, or occlusal space
9. Anticipated final margin placement

Radiographic Analysis

1. Level of alveolar crest
2. Apical extent of fracture or caries
3. Pulpal involvement
4. Root length
5. Root form
6. Furcation
7. Crown-to-root ratio (at present or post-treatment)
8. Root trunk length

Note: The advantages of retaining a tooth in terms of its significance in the overall treatment plan must be weighed against the extent of all procedures needed to properly restore the tooth (Allen, 1993). In other words, if the procedures are too extensive, it is sometimes better to consider extraction depending on the importance of the tooth.

Contraindications and Limiting Factors

1. Inadequate crown-to-root ratio
2. Nonrestorability of caries or root fracture
3. Esthetic compromise
4. High furcation
5. Inadequate predictability
6. Tooth arch relationship inadequacy
7. Compromise of adjacent periodontium or esthetics
8. Insufficient restorative space
9. Nonmaintainability

Note: Orthodontic intrusion or extrusion may be able to overcome some of these factors.

Sequence of Treatment (Allen, 1993)

1. Clinical and radiographic evaluation
2. Caries control
3. Removal of defective restorations
4. Placement of provisional restorations
 - a. Control inflammation

- b. Better assessment of crown lengthening required
- c. Improved surgical access, especially interproximally
- d. Enhanced predictability of margin placement postsurgically

5. Endodontic therapy
 - a. Precedes surgery
 - b. If not possible, then completion is 4 to 6 weeks postsurgery
6. Control of gingival inflammation
 - a. Plaque control
 - b. Scaling and root planing
7. Reevaluation for
 - a. Orthodontic treatment
 - b. Surgical therapy
8. Surgery

Note: Rosenberg and colleagues (1999) recommended that if a greater amount of coronal tissue growth is required, supragingival provisionalization should be performed 3 weeks after the surgical procedure.

Surgical Diagnosis and Treatment

Kois (1994) stated that only 3 mm is necessary to satisfy the requirements for a stable biologic width (2.04 biologic width; 1 mm sulcus depth). Because the sulcus follows the osseous crest, he recommended determining the total dentogingival complex by probing through the sulcus to the gingival crest and described three osseous crest locations (Table 18-1).

Bragger and colleagues (1992) showed that creating a distance of 3 mm from the alveolar crest to the future reconstruction margin was stable periodontally for up to 6 months.

Table 18-1

Location	Crest		Treatment
	Facial DGC (mm)	Interproximal DGC (mm)	
Low	> 3	> 3–4.5	No
Normal	3	3–4.5	No
High	< 3	< 3–4.5	Yes

DGC = dentogingival complex.

Ingber and colleagues (1977) stated “that average measurements do not necessarily reflect any one clinical situation..., however, they do establish a basis upon which decisions can be made. Therefore, the 3 mm biologic width is a variable average, which may not prevent marginal impingement or adequate tooth exposure” (see Vacek and colleagues, 1994). Herrero and colleagues (1995) noted that most clinicians attempting to expose 3 mm of tooth structure failed to do so, suggesting that greater than 3 mm was required. Rosenberg and colleagues (1980 and 1999) and Weinberg and Eskow (2000) recommended a distance of 3.5 to 4 mm, whereas Wagenberg and colleagues (1989) recommended at least 5 to 5.25 mm.

Pontoriero and Carnevale (2001) recently studied 84 crown-lengthening procedures in 30 patients for up to 12 months postoperatively. They found that the initial 3.7 ± 0.8 mm interproximal crown exposure was reduced to only 0.5 ± 0.6 mm of clinical exposure owing to 3.2 ± 0.8 mm of interproximal tissue regrowth or rebound. The degree of tissue rebound varied with tissue biotype (a thick biotype had significantly greater rebound). They concluded that when crown lengthening,

1. A greater removal of osseous support should be considered.
2. In esthetic areas, sulcular marginal placement should await final gingival stability.

This need for adequate bone removal is supported by Lanning and colleagues (2003), who showed that with ≥ 3 mm of osseous reduction, a stable biologic width and adequate tooth exposure were both achievable and maintainable at 3 months.

Presurgical Analysis

Smukler and Chaibi (1997) recommended the following presurgical clinical analysis prior to crown-lengthening procedures:

1. Determine the finish line prior to surgery.
2. If nondeterminable, it should be anticipated.
3. Transcervicular circumferential probing prior to surgery is performed for establishing the biologic width.
 - a. Surgical site
 - b. Contralateral site
4. The biologic width requirements will determine the amount of alveolar bone removal.

5. The combination of biologic width and prosthetic requirements determines the total amount of tooth structure necessary for exposure.
6. Tooth surface topography, anatomy, and curvature are analyzed for determining
 - a. Osseous scallop
 - b. Gingival form

Note: Dibart and colleagues (2003) showed that mandibular molars have a critical distance requirement of 4 mm of root trunk length, after which further crown lengthening results in a high degree of furcation involvement.

Procedure for Crown Lengthening

1. Preoperative temporization or, if possible, additional sufficient interproximal tooth structure should, where possible, be removed at the time of surgery to provide adequate interproximal access.
2. Inverse-beveled incisions are used, especially palatally, for reduction of bulky tissue.
3. Flaps are extended at least one tooth anterior and posterior to the affected area to permit adequate osseous surgery to be performed.
4. Maximum preservation of keratinized gingiva is recommended (4–5 mm) if intrasulcular marginal placement is critical.
5. Rule: The scalloping of the flap should anticipate the final underlying osseous contour, which is most prominent anteriorly and decreases posteriorly.
6. Rule: The scalloping of the flap should reflect the patient's own anticipated healthy gingival architecture (Oschenbein and Ross, 1969, 1973).
7. The flap is reflected as a full-thickness flap if
 - a. There is an adequate zone of keratinized gingiva
 - b. Postsurgical flap positioning will not be a problem

The flap is reflected as a full-thickness flap to the mucogingival junction and then split apically if (Becker and colleagues, 1998; Rosenberg and colleagues, 1999)

 - a. A minimum zone of keratinized gingiva is present and the flap margin will be positioned at or below the crest of bone.
 - b. Difficulty with postsurgical placement and additional flap stability is required.

8. Proper degranulation is critical for
 - a. Reduced bleeding
 - b. Visual differentiation of
 - Osseous topography
 - Tooth structure
 - Apical extent of
 - Decay
 - Margins
 - Fracture
 - Ostectomy and osteoplasty
9. Rule: Osteoplasty, if necessary, is performed prior to ostectomy.
10. Ostectomy is performed to establish at least 4 mm of healthy tooth structure above the osseous crest.

Note: To avoid damage to adjacent teeth, it is strongly recommended that Brassler end-cutting burs (958c; 957c) be used for performing interproximal ostectomy.

11. Ostectomy and scalloping of the bone buccally and lingually are now performed not only on the affected tooth but also onto the adjacent teeth for blending and gradualization of osseous architecture.
12. The degree of osseous scalloping required is determined by
 - a. Periodontal biotype
 - b. Degree of interproximal ostectomy performed. The broader and wider the interproximal area, the flatter the gingival architecture.
 - c. Tooth position anteroposteriorly: scalloping decreases anteroposteriorly.
13. Suturing: Flap position postsurgically is determined by the quantity of keratinized gingiva present:
 - a. Wide zone (> 4 –5 mm): flap positioned 1 mm coronal to the osseous crest
 - b. Normal zone (3 mm): flap positioned at the osseous crest
 - c. Narrow zone (< 3 mm): flap positioned below the crest of bone (partial-thickness flap) or gingival augmentation or supra-gingival marginal placement

Note: The closer the flap is approximated to the bone postsurgically, the greater the tissue rebound and the longer the healing period (6 months) (Deas and colleagues, 2004).

The clinical procedures are seen in Figures 18-1 to 18-7.



FIGURE 18-1. Basic technique. *A*, Preoperative view of a broken-down tooth. *B*, Initial scalloped incision. *C*, Buccal-palatal view of scalloped incisions. *D*, Removal of inner flap and odontoplasty to gain interproximal access. *E*, Flap reflection and degranulation. *F*, Adequate biologic width after osseous surgery. *G*, Suturing with vertical mattress sutures for flap positioning. *H*, Final prosthetics (courtesy of Dr. Michael Katz, Westport, MA).



FIGURE 18-2. Osseous surgery for crown lengthening prior to prosthodontics: subgingival margins. *A*, Before surgery, the old bridge was removed. *B*, Flaps reflected. Margins approximate bone and impinge on biologic width. *C*, Cuspid lengthened 3 mm below margins. *D*, Central incision lengthened 3 mm below margins. *E*, Flaps apically positioned and sutured. *F*, Eight months later, the case is complete.



FIGURE 18-3. Crown lengthening: gummy smile owing to maxillary extrusion. A and B, Initial clinical view of overeruption of the maxillary anterior segment and deep overbite. C and D, Clinical views of increased maxillary convexity and severe attrition of the lower teeth. E and F, Crown lengthening of the maxillary and mandibular teeth is completed and the flaps are stabilized with vertical mattress periosteal sutures. G and H, Final healing 3 months postoperatively. I and J, Final prosthetics on teeth 7 to 10 and 23 to 26. Note the excellent gingival occlusal line relationship. K, Correction of deep overbite. L, Final smile. Note the symmetry of the occlusal and lip lines. Compare with K (prosthetics courtesy of Dr. David Edwards, West Bridgewater, MA).



FIGURE 18-4. Osseous surgery for crown lengthening. *A*, Initial view. Note gingival asymmetry between the right and left sides. *B*, Temporary crowns removed. Note the inadequate tooth structure. *C*, Flap reflected. Inadequate biologic width. *D*, Osseous surgery complete. Compare with *C*. *E*, Palatal view of completed osseous surgery. *F* and *G*, Buccal and occlusal views of suturing. *H*, Final prosthetics. Compare with the preoperative view. Note maintenance of interproximal papilla on teeth 6 to 8.

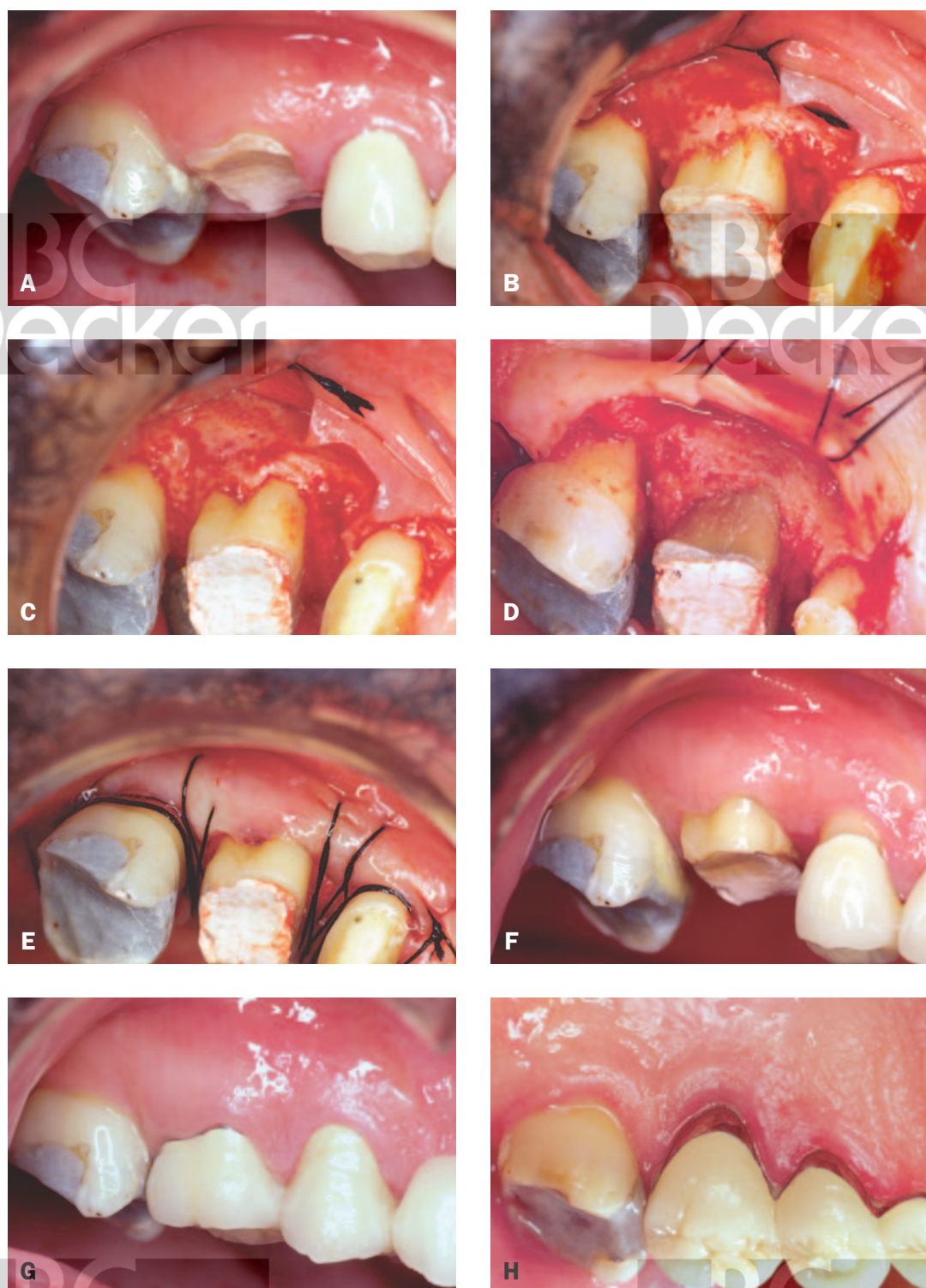


FIGURE 18-5. Osseous surgery for crown lengthening. *A*, Initial view. Tooth with inadequate tooth structure. *B*, Flap reflection. *C*, Osseous contour complete. Note scallop in the furcation area to avoid exposure and create positive architecture. *D*, Total osseous surgery completed. *E*, Vertical mattress sutures. *F*, Final healing 4 months postoperatively. Note tissue rebound. *G* and *H*, Final prosthetics, buccal and palatal views (courtesy of Dr. Joe Nash, Brockton, MA).



FIGURE 18-6. Crown lengthening: tissue rebound. A, Initial view. Teeth 8 and 9 require crown lengthening. B, Submarginal scalloped incision. C, After osseous surgery. D, Suturing. E, Final prosthetics completed 11 months after surgery. Note ideal contours and healing. F, Note complete tissue rebound 2 years later.



FIGURE 18-7. Crown lengthening for gingival symmetry prior to anterior prosthetics. *A* and *B*, Before, with extruded premaxilla, unsightly gingival display, uneven occlusal design, and loss of papilla between teeth 8 and 9. *C*, Submarginal scallop flap. *D*, Flap reflected with maintenance of interproximal papulla. *E*, Osseous surgery completed. *F*, Flap is apically positioned and sutured. *G* and *H*, Final prosthetics completed. Note excellent gingival symmetry and papillary form (prosthetics courtesy of Dr. Michael Katz, Westport, MA).



Altered Passive Eruption: The Gummy Smile

Tooth eruption is divided into two phases: active and passive eruption (Weinberg and Eskow, 2000).

Active eruption is the physical movement of the tooth from its prefunctional subgingival position through the gingival tissue, into the oral cavity, and, finally, into functional occlusion (Moss-Salentin and Klyvert 1990). “Functional active eruption is the continued tooth movement due to wear” (Gottlieb and Orban, 1933).

Passive eruption is the continued apical movement of the free gingival margin epithelial attachment or junctional epithelium and connective tissue attachment that occurs after the tooth reaches functional occlusion (Gottlieb and Orban, 1922; Manson, 1963). Gargiulo and colleagues (1961) classified and divided passive eruption into four stages:

- Stage I: The sulcus and junctional epithelium (JE) are on the enamel.
- Stage II: The sulcus is on the enamel. The JE is part on the enamel and part on the cementum.
- Stage III: The sulcus is at the cementoenamel junction (CEJ) and the JE is completely on the cementum.
- Stage IV: The sulcus and the JE are apical to the CEJ.

Note: During stages I and II, the JE was longer, whereas the connective attachment remained constant (Figure 19-1).

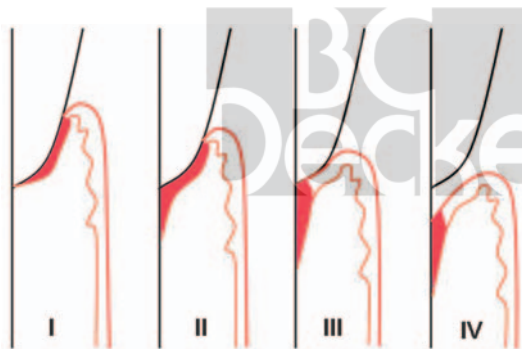


FIGURE 19-1. Stages of passive eruption. I. JE on enamel; II. JE on enamel and cementum. III. JE at CEJ; IV. JE apical to CEJ.

Goldman and Cohen (1968) termed the failure of the tissue to adequately recede to a level apical to the cervical convexity of the crown as “altered passive eruption.” Volcansky and Cleaton-Jones (1974) described the tissue’s failure to reach the CEJ junction as “delayed passive eruption.” Volcansky and Cleaton-Jones (1976) reported that 12.1% of 1,025 patients with a mean age of 24.2 years \pm 6.2 years displayed delayed passive eruption. In 1979, Volcansky and Cleaton-Jones confirmed the observations of Black (1902), Gottlieb and Orban (1933), and Manson (1963) “that passive eruption of the teeth continues with increasing age.” Tjan and colleagues (1984) noted its occurrence as 7% in men and 14% in women.

Classification of Delayed or Altered Passive Eruption

Coslet and colleagues (1977) proposed a classification, which is still used today, for the purposes

of differential diagnosis and treatment of altered passive eruption (Figure 19-2):

Gingival-Anatomic Crown Relationships

Type I. The gingival margin is incisal or occlusal to the CEJ, and the mucogingival junction is apical to the crest of bone, and there is a wider gingival dimension than generally accepted as the mean, as given by Bowers (1963) and Löe and Aniamo (1966).

Type II. The gingival dimension is normal. The free gingival margin is incisal or occlusal to the CEJ, and the mucogingival junction is positioned at the CEJ.

Alveolar Crest–CEJ Relationships

Subgroup A. The alveolar crest is located 1.5 to 2 mm from the CEJ.

Subgroup B. The alveolar crest is coincident with the CEJ.

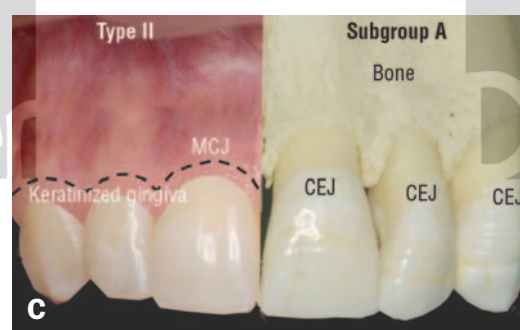
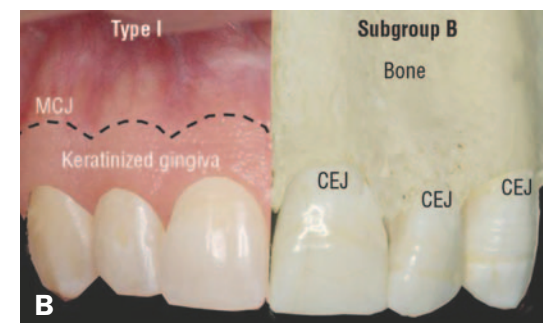


FIGURE 19-2. Classification of delayed or altered passive eruption. A, Type I, subgroup A. B, Type I, subgroup B. C, Type II, subgroup A. D, Type II, subgroup B.

Diagnosis

Differential diagnosis is accomplished by determining the

- 1. Width of keratinized gingiva
- 2. Position of the mucogingival junction
- 3. Alveolar crest location by transgingival probing through the sulcus under anesthesia to the crest of bone

Treatment

Treatments for the gummy smile or altered passive eruption are summarized in Table 19-1 and outlined in Figure 19-3.

Surgical Evaluation for Esthetic Symmetry

In evaluating the anterior segment for surgery, you must not forget to also analyze the following for symmetry:

- 1. Gingival line
- 2. Interpapillary line
- 3. Individual gingival heights
- 4. Posterior segments both individually and to each other
 - a. Gingival line
 - b. Occlusal plane
- 5. Incisal, contact, and gingival lines
- 6. Commission line

Note: Remember, you want parallelism of the horizontal, gingival, and incisal planes with the interpapillary line.

Davis (1999) pointed out that when the gingival tissues are removed and more tooth structure is exposed, the balance is shifted, with more positive space (tooth structure) being created at the expense of negative space (gingival tissues).

The clinical procedures for Type I-B and Type II-A and B are shown in Figures 19-4 to 19-10.

To avoid esthetic compromises, it is absolutely imperative that the interproximal tissues be completely retained and that the surgery be performed on the facial aspects of the teeth only.

Table 19-1 Treatment for the Gummy Smile or Altered Passive Eruption	
Condition	Treatment
Type I-A	Gingivectomy
Type I-B	Gingivectomy or scalloped inverse-beveled flap to the CEJ, positioned (unrepositioned) flap, and osseous resection
Type II-A	Apically positioned flap (repositioned flap)
Type II-B	Apically positioned flap with osseous resection

CEJ = cementoenamel junction.

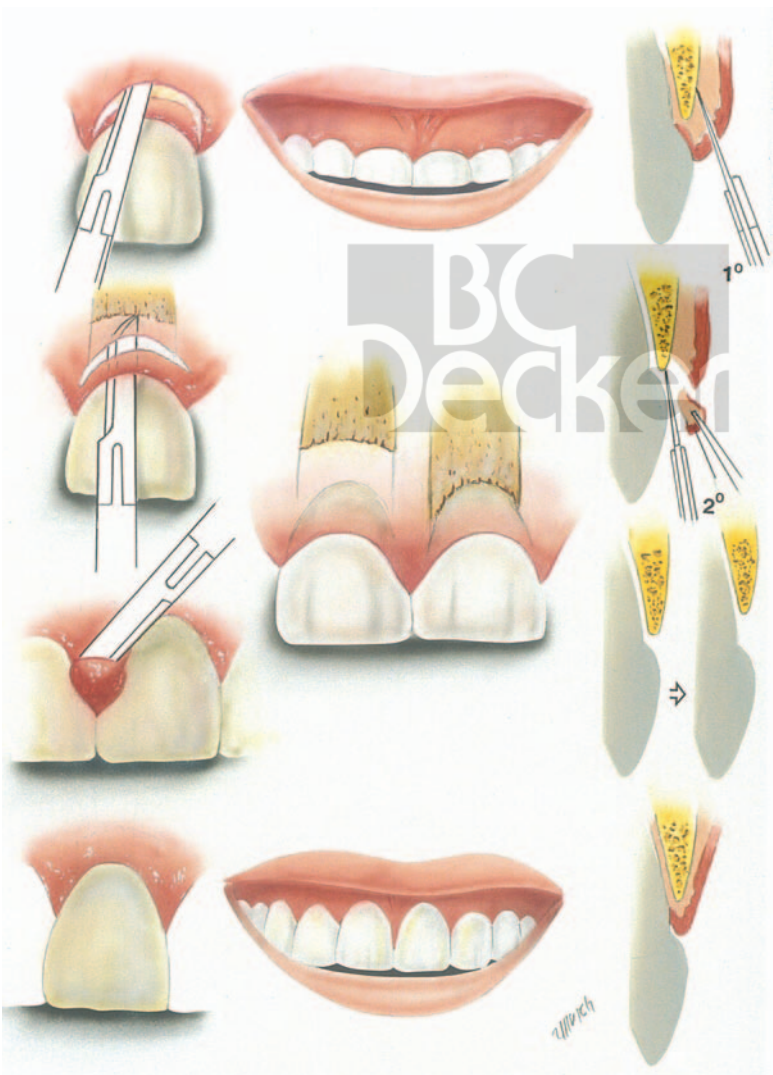


FIGURE 19-3. Diagrammatic overview of different type treatments. The right side is Type I, subgroup A. The left side is for Type I, subgroup B, or Type II subgroup A or B.

A flap with or without osseous surgery is required any time soft tissue removal would leave you with less than 3 to 5 mm of keratinized gingiva (Allen, 1988).

- 1. A horizontal or scalloped partial or split incision is made on the facial aspect of the interproximal papilla above the CEJ but below the tip.
- 2. The interproximal incision is carried down to the buccal aspect of the osseous crest interproximally and extended buccally as a full-thickness mucoperiosteal flap.
- 3. The placement of the buccal incision (sulcular or submarginal) and the degree of facial scalloping labially or buccally will vary with the
 - a. Zone of keratinized gingiva
 - Wide zone: scalloped buccal incision to the CEJ
 - Narrow zone: crestal or intrasulcular incision
 - b. Location of the CEJ
 - c. Amount of tooth exposure required

- d. Root prominence, topography, and degree of curvature
- 4. The flap is extended horizontally and laterally to the lateral extent of the smile line, which most often is the first or second bicuspid area (Robbins, 1999).
- 5. Full-thickness mucoperiosteal flap reflection
- 6. Osseous surgery is required for establishment of a
 - a. Biologic width of 3 mm (chapter 18 “Crown Lengthening”)
 - b. Smile line: vertical extension of lips 1 to 2 mm above the CEJ or gingival line
 - c. Gingival line
 - Central incisors and cuspids have the same gingival height.
 - Lateral incisors are exposed 1 to 2 mm coronal to the central incisors.
 - Gingival height of convexity
 - Central incisors—distal third
 - Lateral incisors—centrally located
 - Cuspids—distal third



FIGURE 19-4. Altered passive eruption – Flap (Type I, B). A and B, Initial view showing excessive gingival display and short teeth. C, Short teeth. D, Flap showing bone to CEJ (Type I, subgroup B). E, After osseous surgery and establishment of biologic width. F, Interrupted sutures without papilla. G, Final result (6 months later). Compare to Figure B. H, Final smile line. Compare to figure A. Note smile enhancement by less negative space (gingival tissue) and change in lip line.



FIGURE 19-5. Gingival enlargement – Gingivectomy. A, Initial view showing gummy smile. B, Close-up view displaying wide zone of keratinized gingiva. C, Outline of incision. D, Gingivectomy and frenectomy. E and F, Final smile and clinical view. Compare to Figures A and B.



FIGURE 19-6. Altered passive eruption (Type I, A) A and B, Initial view showing short teeth with gummy tissue smile. C, Initial scalloped incision and removal of inner flap. D, Full thickness flap with complete papillary preservation. Bone at CEJ. E, Completion of osseous surgery for biologic width. Compare to figure C. F, Interrupted papillary suture. G and H, Final results (8 months). Compare to Figures A, B. and G, H, Pre- and postoperative views. Note complete transformation of smile.



FIGURE 19-7. Gummy smile/prosthetics (Type I–A). *A* and *B*, Initial views showing “gummy smile” and short clinical crowns. Patient requires new crowns 6–11. *C*, Initial scalloped incision – wide zone of keratinized gingiva. *D*, Inner flap removed. *E* and *F*, Pre- and post views of osseous level – right side. *G* and *H*, Pre- and post views of osseous level – left side. Note that the osseous level must be enough to lengthen crowns and create a biologic width. *I*, Final suturing. Vertical mattress interpapillary sutures for flap stabilization. *J*, Final healing 7 months later. Note ideal gingival contours and preservation of interproximal tissue. *K* and *L*, Final crowns completed and final smile. Compare to figures *A* and *B*. (Prosthetics courtesy of Dr. William Irving, Needham, MA.)



FIGURE 19-8. Gummy smile – Tooth extrusion. A and B, Initial views. Tooth extrusion requires not only removal of gingival tissue but apical movement of contact point on teeth 8 and 9. C, Reduction of gingival tissue *facially and interproximally*. D, Final healing. Teeth lengthened and contact point to be moved. E and F, Final crowns and smile. G and H, Pre -and postoperative look and gingival contours. Note that for maximum esthetic results, prosthetics should have included teeth #5, #1 and #12.

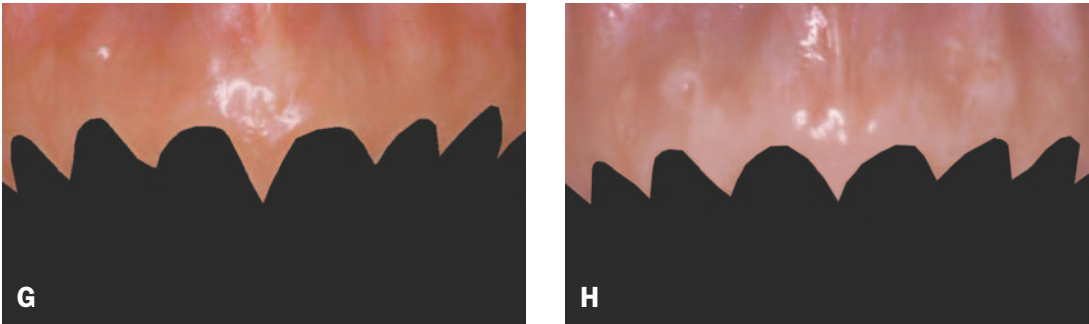


FIGURE 19-9. Gummy smile – Type I, subgroup B treated by mucoperiosteal flap. A and B, Preoperative view of gummy smile and short teeth. C, Flap sutured to position. D, Final healing. E, Final smile. Compare to Figure A.



FIGURE 19-10. Triad stent for diagnosis and surgical guide. A and B, Preoperative smile and clinical views of short teeth, gummy smile, and unacceptable restorations. C, Triad material. D, Material fitted to case. E, Rough outlining. F, Material trimmed after initial polymerization. G, Final contouring after final polymerization. H, Varnish for high finish. I, Final stent after varnish applied. J and K, Stent try in. Note excellent change in esthetics for patient to view. (Cuspids are too long and should have been trimmed.) L, Final esthetic case. Compare to Figure A. M and N, Stent and final crowns. Note similarity. (Laboratory work courtesy of Ira Dickerman, Sharon, MA; Prosthetics by Dr. Michael Katz, Westport, MA).

7. The flap is then
 - a. Positioned (unrepositioned flap) (type I) at the CEJ or
 - b. Apically positioned (repositioned) (type II) to the CEJ and sutured.
8. Suturing should avoid compression of the interproximal papilla, which might lead to shrinkage. It is therefore recommended that one of the following suturing techniques be used:
 - a. Facially interrupted sutures
 - b. Intrapapillary mattress sutures
 - c. Continuous intrapapillary suspensory sutures

The clinical procedure for Type I-A (Allen, 1988; Kois, 1994) is shown in Figure 19-7

Gingivectomy with Supracrestal Fiberotomy. If there is at least a 5 mm–wide zone of keratinized gingiva with at least 2 mm of crown coverage. Then

1. A gingivectomy down to the CEJ is performed using a steep beveled incision to thin the tissue.
2. The incision is blended into the adjacent papilla.
3. After removal of the tissue, the gingival tissues are compressed for two minutes.
4. Using sharp dissection, a 15c-scalpel blade is inserted into the facial gingival sulcus down to the crest of bone.
5. The blade is moved in a mesiodistal direction to the interproximal line angles. This will allow reorganization by the dentogingival complex without laying a flap.

Note: There is very little tissue rebound if the gingival margin is properly thinned.

Forced Eruption

In anterior or esthetic zones where surgical crown lengthening for subgingival or subosseous fractures, caries, or endodontic problems is unaccept-

able, forced eruption can serve as an alternative or adjunctive therapy (Johnson and Sievers, 1985), thus preventing needless extraction (Levine, 1997).

Heithersay (1973) first advocated forced eruption of teeth with horizontal fractures. Imber (1975, 1976, 1977, 1989) recommended orthodontic extrusion for periodontal reasons.

Imber (1989) defined forced eruption as a procedure in which a tooth is intentionally moved in a coronal direction using gentle continuous force to effect changes in the soft tissue and bone. The goal is to effect alterations in the soft tissue and underlying bone without concern for special relationships and to facilitate the establishment of a biologic width. This required a minimum of 3 to 4 mm from the osseous crest to the coronal extent of sound tooth structure.

It is recommended that a light continuous force of 20 to 30g be used with suitable anchorage (two teeth) mesially and distally (Johnson and Sievers, 1986; Wang and Wang, 1992). A minimum of 2 weeks is recommended for each millimeter of extrusion (Ingber, 1976). The procedure may be carried out on one, two, or three teeth (Nemcovsky and colleagues, 2001).

Indications

1. Alterations in uneven gingival margins
2. Correction of vertical bony defects
3. Vertical ridge augmentation for implants
4. Nonsurgical crown lengthening
 - a. Esthetically compromised areas
 - b. Subgingival decay
 - c. Tooth fracture
 - d. Endodontic reasons
5. Facilitates establishment of the biologic width

Requirement

1. Adequate root length both pre- and post-treatment
2. Adequate proximal orthodontic anchorage
3. Satisfactory endodontics
4. Patient motivation

Disadvantages

1. Longer time
2. Greater expense
3. Impaired esthetics
4. Compromised oral hygiene
5. Root width disparity with contralateral tooth
6. Limited surgery may still be required

Advantages

1. Conservative
2. Esthetic maintenance
3. Root preservation
4. Low morbidity

Contraindication

1. Inadequate clinical root length

Supracrestal Fiberotomy Modification

Forced extrusion results in the extrusion of not only the tooth but also the underlying bone and soft tissue. This often results in the need for a secondary surgical procedure for final crown lengthening for establishment of an adequate biologic width.

Pontoriero and colleagues (1987) and Kozlowsky and colleagues (1988) advocated a combination of orthodontic extrusion and severance of the supracrestal fibers termed supracrestal fiberotomy, as a means of overcoming the need for a secondary crown-lengthening procedure. They advocated placing a no. 15 scalpel intrasulcularly down to the crest of bone and rotating it 360° about the tooth, thus severing the supracrestal fibers. This will prevent the coronal movement of bone as the tooth is extruded and negate the need for secondary surgery. Berglundh and colleagues (1991) noted that supracrestal fiberotomy failed to entirely prevent coronal migration of the attachment apparatus and increased the presence of gingival inflammation (Figures 19-11 to 19-14).



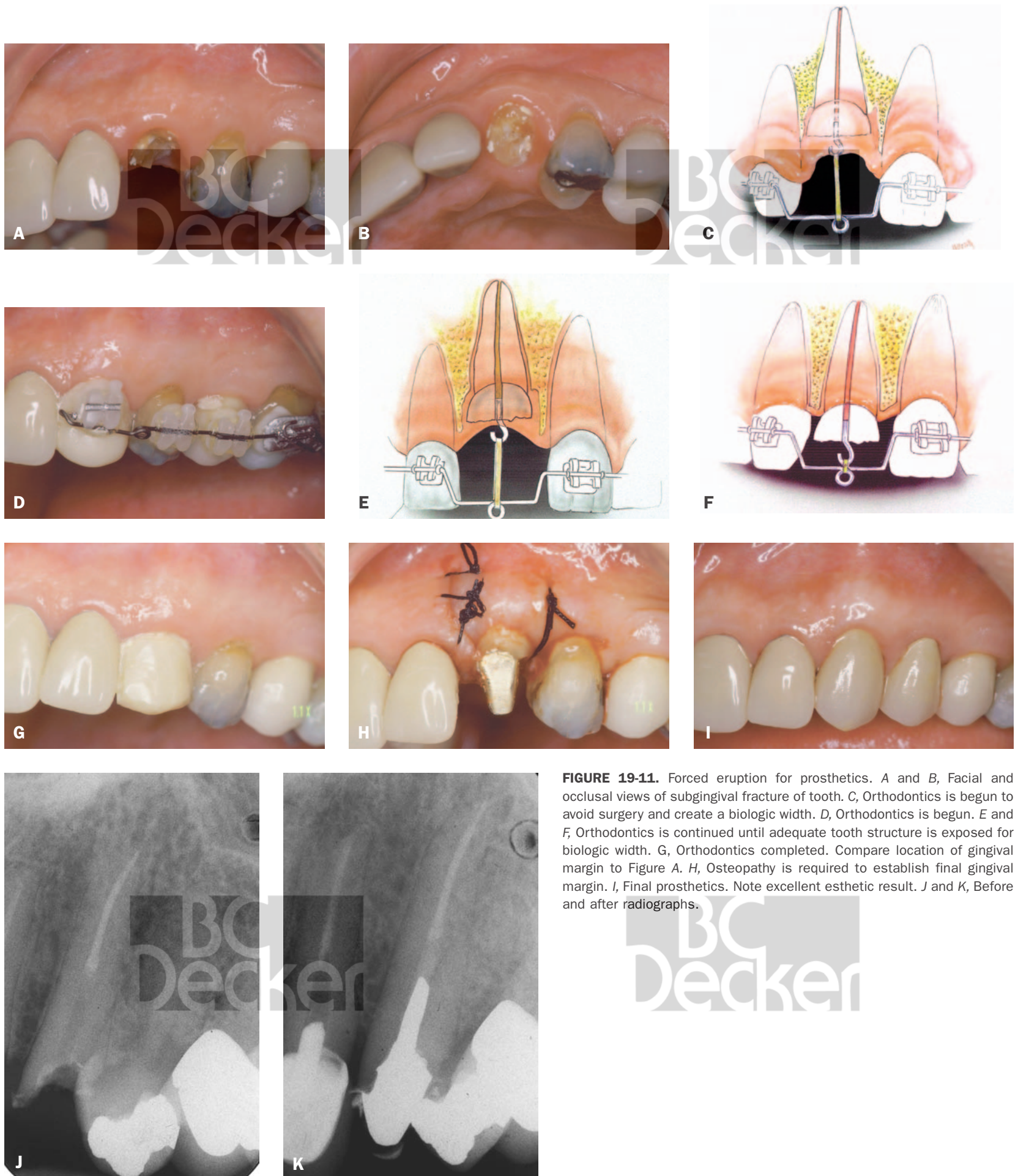


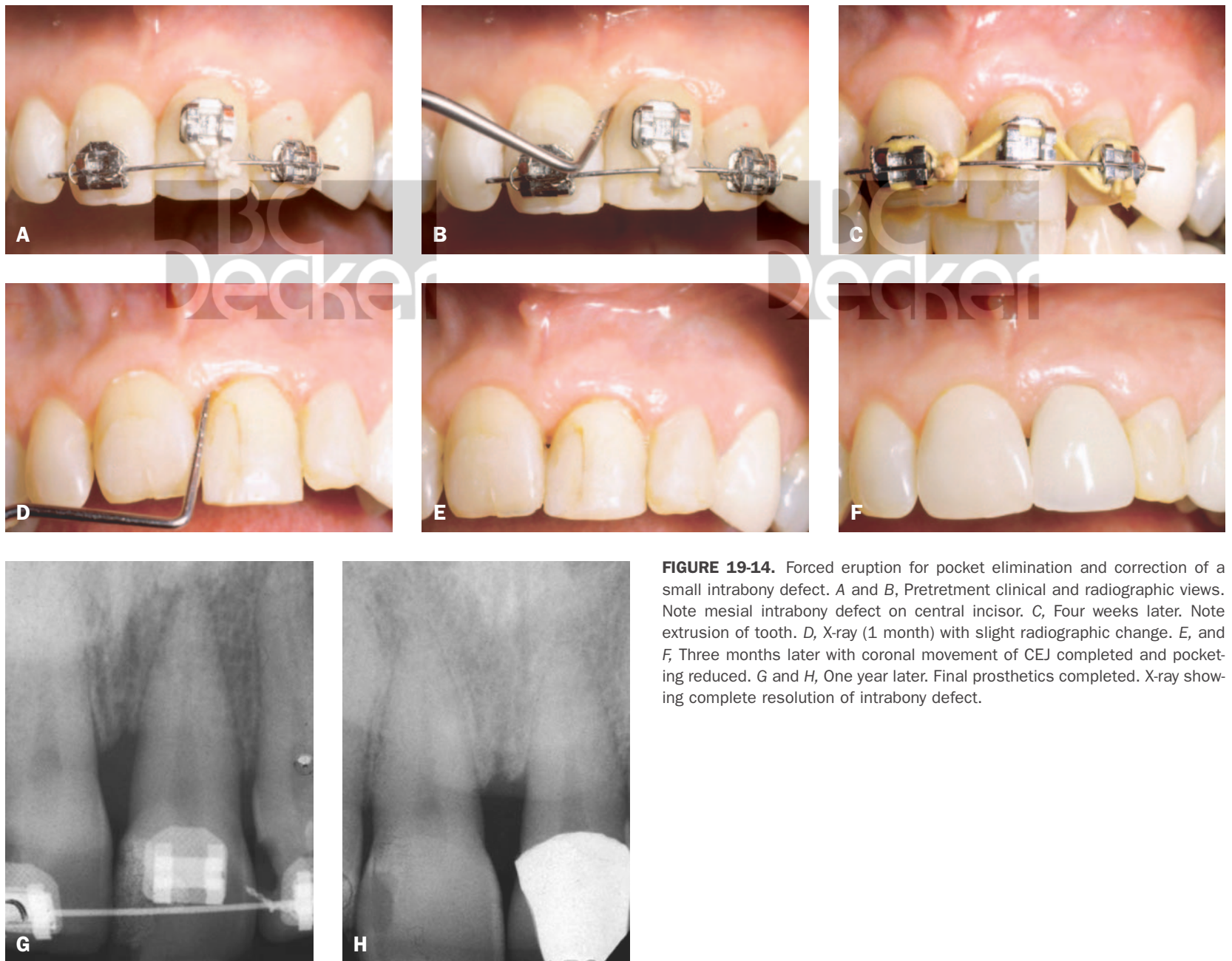
FIGURE 19-11. Forced eruption for prosthetics. A and B, Facial and occlusal views of subgingival fracture of tooth. C, Orthodontics is begun to avoid surgery and create a biologic width. D, Orthodontics is begun. E and F, Orthodontics is continued until adequate tooth structure is exposed for biologic width. G, Orthodontics completed. Compare location of gingival margin to Figure A. H, Osteopathy is required to establish final gingival margin. I, Final prosthetics. Note excellent esthetic result. J and K, Before and after radiographs.



FIGURE 19-12. Forced eruption for prosthetics. A and B, Preoperative clinical view. C, Orthodontics begun. Note apical placement of bracket on tooth #1. D, Final prosthetics. Note that gingival is improved from start. Compare to Figure B. E, F, and G, Preoperative view with and without crown. Final prosthetics. (Prosthetics by Dr. Arnold Rosen, Boston, MA.)



FIGURE 19-13. Forced eruption to uneven gingival margins. A and B, Preoperative view of clinical core and radiograph. C, Initial view showing unsightly long crown on tooth #9 that needs replacement. D, Orthodontics begun for extrusion of tooth #9. E, Completed prosthetic core. (Prosthetics by David Edward, Bridgewater, MA.)





Biomechanical Root Preparation

Periodontal disease, although multifactorial, has been shown to have bacteria, in the form of plaque, as its primary etiologic agent (Loe and colleagues, 1965; Theilade and colleagues, 1966). Bacteria initiate disease in many ways, one of which is by the production of endotoxin (Mergenhausen and colleagues, 1966; Simon and colleagues, 1970, 1971; Synderman, 1972). These endotoxins (complex lipopolysaccharides) have potent inflammatory agents as part of their cell walls and can be found in the cementum of teeth with untreated periodontal disease (Aleo and colleagues, 1974). This cementum-bound endotoxin has been shown to prevent the in vitro growth of

fibroblasts (Aleo and colleagues, 1975; Fine and colleagues, 1980) and to be cytotoxic (Hatfield and Bauhammers, 1971), and although it has been shown that in vitro mechanical removal of cementum is possible and does permit new growth of cells (Aleo and colleagues, 1975; Cogen and colleagues, 1983, 1984), it has also been shown that in vivo total removal of cementum is not possible (O'Leary and Kafrany, 1983; Borghetti and colleagues, 1987) and that trace amounts of endotoxin are left behind (Jones and O'Leary, 1978).

If the ultimate goal of periodontal therapy is restoration of lost support through complete

regeneration or new attachment, then the root must be cleaned of the cementum-bound endotoxins, which are cytotoxic (Wirthlin, 1981) and which prevent regeneration or new attachment (Karring and colleagues, 1980; Lopez and colleagues, 1980). For this reason, topical chemotherapeutic agents have been used for both detoxification and enhancement of new attachment in cosmetic gingival reconstruction (Miller, 1985b) and bone augmentation procedures (Yukna, 1980, 1990). It is also an attempt to overcome the most significant limited factor to new attachment, which is the rapid rate of epithelial proliferation down along the root (Figure 20-1).

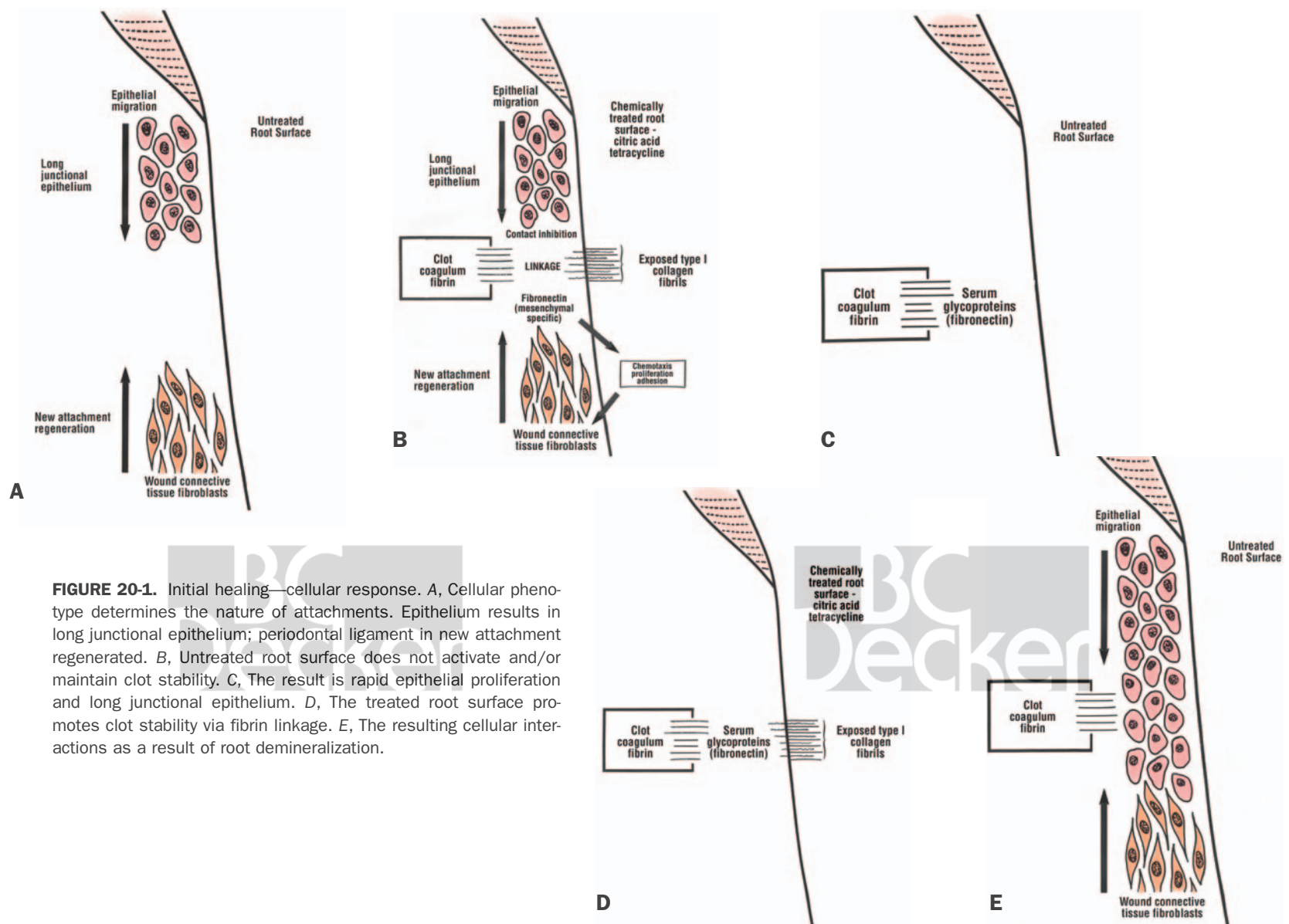


FIGURE 20-1. Initial healing—cellular response. A, Cellular phenotype determines the nature of attachments. Epithelium results in long junctional epithelium; periodontal ligament in new attachment regenerated. B, Untreated root surface does not activate and/or maintain clot stability. C, The result is rapid epithelial proliferation and long junctional epithelium. D, The treated root surface promotes clot stability via fibrin linkage. E, The resulting cellular interactions as a result of root demineralization.

Historically, the use of acids in lieu of scaling and root planing was first reported in the *New York Dental Record* in 1846 and later by Younger (1893, 1897) and Stewart (1899). These early clinicians sought to stimulate inductive activity on diseased root surfaces. Some of them reported attachments and bone induction to the demineralized root surfaces (Register, 1973).

Citric Acid

Register (1973, 1975, 1976), following in the footsteps of the early practitioners, based his rationale on present-day bone induction research (Bang and colleagues, 1967; Dubuc, 1967; Ueomans and Urist, 1967; Urist, 1971), which demonstrated the formation of new bone or cementum on partially or totally acid demineralized allogenic bone or dentine matrix. Register and Burdick (1975) showed that demineralization of the root surface produced cementogenesis and new attachment and that citric acid (CA) (pH 1.0) was the acid of choice, with an optimal application time of 2 to 3 minutes. Sterratt and colleagues (1991) recently found the optimum pH to be 1.42, beyond which less demineralization took place.

Garrett (1978), using scanning electron microscopy (SEM) and transmission microscopy, demonstrated that CA, although having no effect on an unplanned root surface, did produce a 3 to 5 mm zone of demineralization on a planed root surface. He postulated that the failure was due to hypermineralization of the diseased root surface. Polson and colleagues (1984) further demon-

strated by SEM that root planing alone produced a “smear layer” of residual debris, but when combined with CA application (pH 1.0; 2–3 minutes), the smear layer was removed, leaving a “mat-like” collagen surface with exposed dental tubules (Figure 20-2). This demineralization fiber or mat-like surface was further shown in vitro to permit cells cultured from the periodontal ligament and gingival fibroblasts to adhere better to the demineralized root surface (Boyko and colleagues, 1980). It was thought that this was due to exposed collagen rather than to the demineralized root surface (Leighton 1982; Polson and Proye, 1982; Steinberg, 1987).

Animal Studies

These early findings led to a series of animal studies. Through-and-through furcations were studied in dogs (Crigger and colleagues, 1978; Craig and colleagues, 1980; Nilveus and colleagues, 1980; Nilveus and Egelberg, 1980; Ririe and colleagues, 1980; Selvig and colleagues, 1981, 1990), where high rates of bone regeneration and flap reattachment were seen with topical application of CA. It was concluded that the therapeutic use of CA was the critical factor irrespective of other factors.

Reimplantation of teeth in primates was used to study the interrelationship between exposed root surface connective tissue fibers and reattachment (Polson and Caton, 1982; Polson and Proye, 1982, 1983; Proye and Polson, 1982). It was found that “reattachment was dependent upon exposed healthy connective tissue root fibers” and further than in cases in which the fibers had been removed, either surgically or by disease, CA application prior

to reimplantation permitted reattachment to occur (Polson and Caton 1982). Polson and Progue (1982) concluded that “remnants of connective tissue fibers on the root resulted in reattachment whereas surgical denudation...resulted in epithelial migration.”

The initial stages of clot formation and stabilization on CA-demineralized roots were found to be by a fibrin attachment via “arcade-like” formations (Steinberg, 1987). This fibrin-collagen linkage between the gingival fibers of the clot and the CA-demineralized root is mediated by a plasma fibronectin mechanism (Polson and Proye, 1982) (Figure 20-3), which is an essential precursor to new attachment and is initiated by platelet activation (Steinberg, 1987). Platelet activation is dependent on root surface connective tissue and does not occur on surgically planed or diseased root surfaces, resulting in clot instability (Polson and Proye, 1983; Wikesjo and colleagues, 1991).

These findings may explain why human clinical studies using several different periodontal procedures (ie, scaling and root planing, modified Widman flap, open-flap curettage, apically positioned flap) have shown healing only by a long junctioned epithelium.

Human Clinical Studies

Human clinical trials, although sparse, with studies showing both positive (Cole, 1980; Shiloah, 1980; Bogle and colleagues, 1981; Common and McFall, 1983; Frank, 1983; Stahl, 1985; Gantes and colleagues, 1988a, 1988b; Schallhorn and McClain, 1988; Hanes and Polson, 1989; Stahl and Froum, 1991; McClain and Schallhorn 1993) and negative (Stahl and Froum, 1977; Ibbott and colleagues,

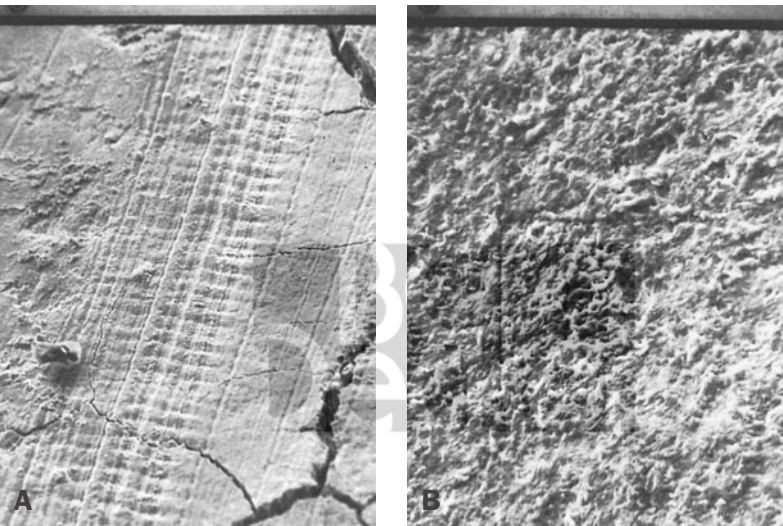


FIGURE 20-2. Removal of the smear layer. A, Scaled root surface showing smooth surface but closure of dentinal tubules (×1,500 original magnification). B, Scaled root surface after exposure to a saturated solution of citric acid (pH 1.0 for 3 minutes). The smear layer has been removed, the dentinal tubules have been exposed, and the fibrous matrix has been exposed (×1,500 original magnification). Contributed by Knut A. Selvig, Bergen, Norway.

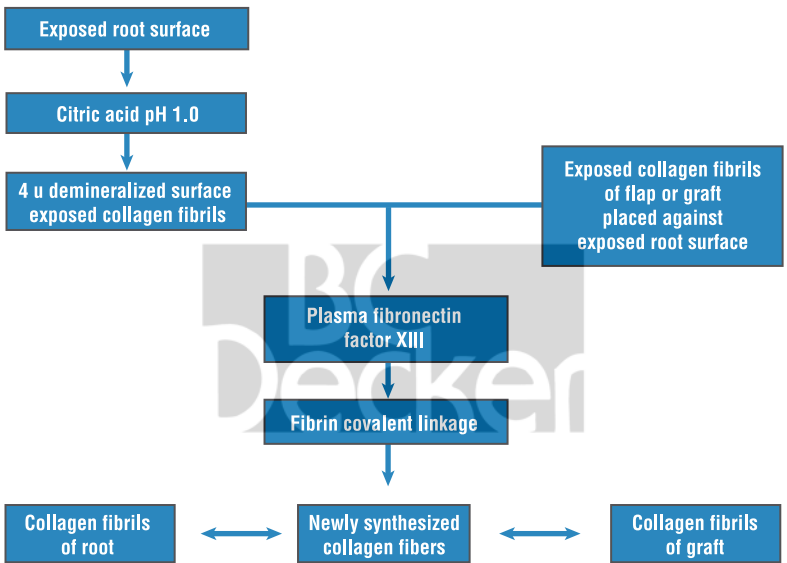


FIGURE 20-3. Outline of citric acid mechanism for gaining root coverage. Note that the benefits of the use of citric acid in humans have not been substantiated.

1985; Gottlow and colleagues, 1986; Marks and Mehta, 1986; Handelsman, 1991; Lamell and colleagues, 1998) results, have shown that there is a strong indication that when CA is combined with coronally positioned flaps, a positive result can be achieved. A number of clinical studies (Gantes and colleagues, 1988, 1991) have shown that in Class II molar furcations (mandibular, buccal, and/or lingual; maxillary buccal), the combination of CA demineralization and coronal flap placement with or without demineralized freeze-dried bone allografts resulted in significant bone fill (66 to 70% fill of defect volume; 44 to 67% showing 100% bone fill). Stahl and Froum (1991) (Figure 20-4), confirming the earlier work of Cole (1980), showed an average gain in probing attachment of 4.5 mm in CA-demineralized coronally anchored sites (as opposed to the 1.7 mm gain for coronally anchored barrier membrane), with histologic evidence of new cementum with functionally inserted fiber in the calculus notch of all coronally anchored CA-demineralized sites.

It can be concluded from the research that CA demineralization enhances new attachment or reattachment and regeneration by one or more of the following mechanisms:

1. Antibacterial effect (Daly, 1982)
2. Root detoxification (Aleo and colleagues, 1975)
3. Exposure of root collagen and opening of dentinal tubules (Polson and colleagues, 1984)
4. Removal of the smear layer (Polson and colleagues, 1984)
5. Initial clot stabilization (Wikesjo, 1991)
6. Demineralization prior to cementogenesis (Register, 1975, 1976)
7. Enhanced fibroblast growth and stability (Boyko and colleagues, 1980)
8. Attachment by direct linkage (Stahl and Tarnow, 1985; Stahl, 1986) or periodontal without cementogenesis (Levine and Stahl, 1972; Masileti, 1975)
9. No adverse effects to either the pulp (Hagner and Polson, 1986) or periodontal tissues (Polson and Haynes, 1986) have been reported.

Note: Recently, in a series of studies comparing ethylenediaminetetraacetic acid (EDTA) and CA, Blonlöf (1996, 1995a, 1995b, 2000) reported greater tissue necrosis and greater dissolution of the exposed collagen bundles with CA than with EDTA (see the section on EDTA).

Tetracycline Hydrochloride

Tetracycline hydrochloride (TTC) has recently been used for acid root demineralization because it provides the same benefits as CA:

1. Antibacterial (Baker and colleagues, 1983a)
2. Exposure of root collagen and opening of the dentinal tubules; removal of the smear layer (Wikesjo and colleagues, 1986)
3. Demineralization (Bjorvatn, 1983)
4. Detoxification of the root surface (Terranova and colleagues, 1986)
5. Permits attachment by direct linkage with or without cementogenesis (Alger and colleagues, 1990)

It also has a number of other advantages:

1. Anticollagenase activity (Golub and colleagues, 1984)
2. Positive effects when placed in bone grafts (Al-Ali and colleagues, 1989; Papelars and colleagues, 1991)
3. Substantively antibacterial for 2 to 14 days (Baker, 1983b)

4. Enhances bone repair in extraction sockets (Hars and Massler, 1972)
5. Binds more fibronectin (FN) to the demineralized surface (Terranova, 1986)

Unfortunately, there appears to be a dosage-dependent effect (> 100 mg) on fibroblastic cell attachment and spreading (Somerman and colleagues, 1988), about which they will not occur. Further, in comparative studies with CA, TTC has been found not to establish new connective tissue attachment (Haynes and colleagues, 1991). TTC may therefore require higher concentrations ($> 0.5\%$) and/or longer application times (> 5 minutes). Finally, unlike for CA, no human histologic or clinical studies show the positive effects of TTC root demineralization.

Note: The most recent clinical studies (Alger and colleagues, 1990; Machtei and colleagues, 1993; Parashis and colleagues, 1993; Darhous and colleagues, 1995) have been inconclusive as to the beneficial effects of TTC.

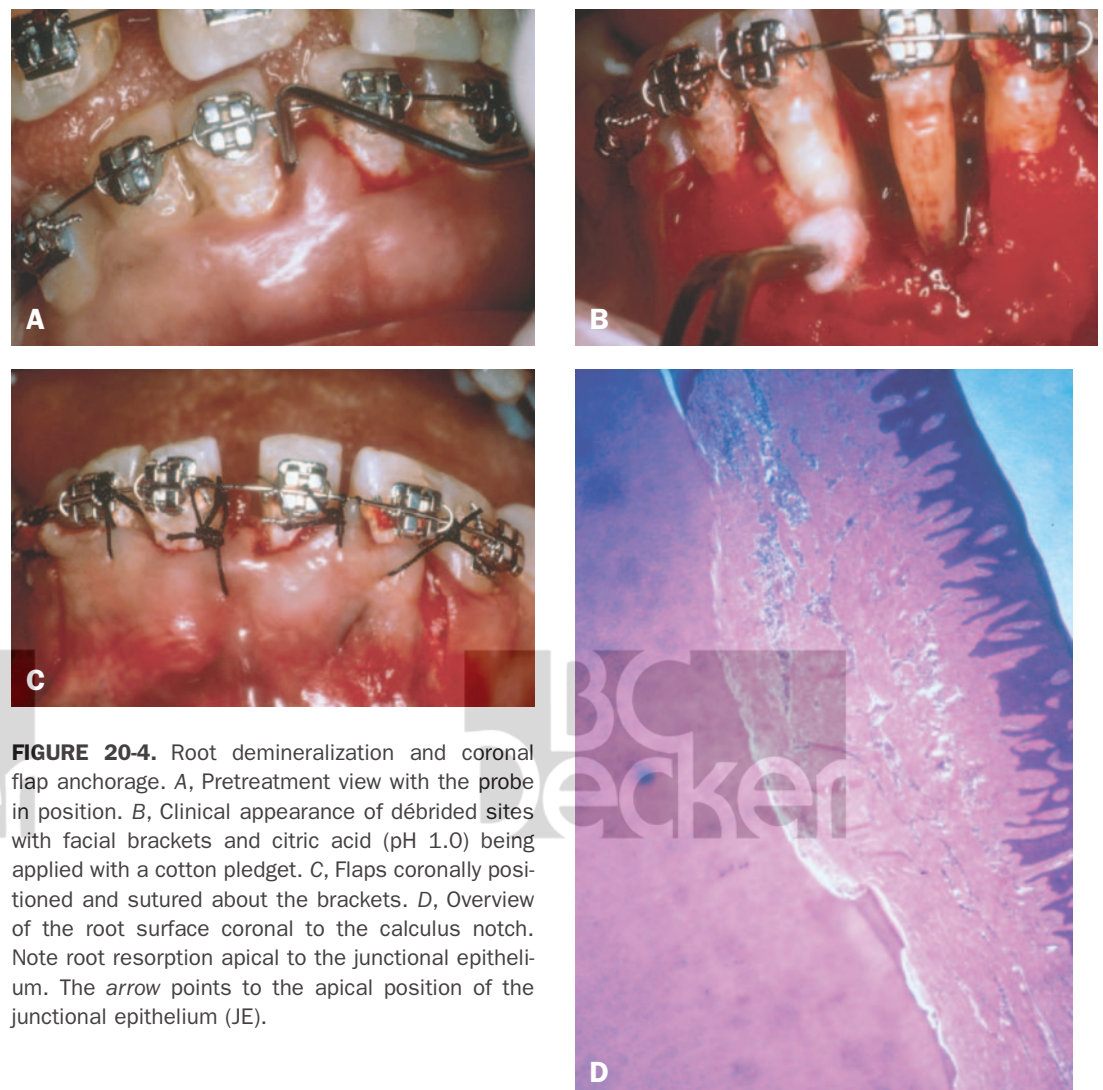


FIGURE 20-4. Root demineralization and coronal flap anchorage. A, Pretreatment view with the probe in position. B, Clinical appearance of débrided sites with facial brackets and citric acid (pH 1.0) being applied with a cotton pledget. C, Flaps coronally positioned and sutured about the brackets. D, Overview of the root surface coronal to the calculus notch. Note root resorption apical to the junctional epithelium. The arrow points to the apical position of the junctional epithelium (JE).

Ethylenediaminetetraacetic Acid

Twenty-four percent EDTA is a neutral pH (7.0) etching agent recommended for root detoxification and demineralization of root surfaces and has been shown to have the following advantages over low pH (1.0) etching agents similar to CA:

1. Equally effective in smear layer removal (Blomlöf and colleagues, 1997)
2. Exposes more intact collagen bundles (Blomlöf and colleagues, 1996)
3. Less necrosis of the periodontal tissues (Blomlöf and Lindskog, 1995a)
4. Does not dissolve root collagen fibers (Blomlöf and colleagues, 2000)
5. Greater histologic attachment with less junctional epithelium formation (Blomlöf and colleagues, 1996)

The studies indicate that EDTA produces a biocompatible root surface with greater exposure of intact collagen bundles that is more conducive for cell repopulation and periodontal fibroblast chemotaxis (Posthethwane and colleagues, 1978; Fernyhaugh and Page, 1983), without the surrounding tissue necrosis and dissolution of the collagen matrix.

Note: There are no studies comparing EDTA and TTC.

Fibronectin

Fibronectin (FN) is a high-molecular-weight glycoprotein (molecular weight = 440,000) that is found in the extracellular tissue and is the main component that holds the clot together (Seelich and Redl, 1979; Baum and Wright, 1980). It promotes cell adhesion (Kleinman and colleagues, 1976; Boyko and colleagues, 1980;) to both collagen (Ruoslahti and colleagues, 1980) and scaled root surfaces (Terranova and Lundquist, 1981) and has a chemotactic effect on fibroblasts and

mesenchymal cells (Kleinman and colleagues, 1981; Mensing and colleagues, 1983).

Periodontally, the application of FN to partially demineralized roots has been shown significantly to (1) enhance the effects of demineralization with regard to new attachment (Caffesse and colleagues, 1978b) and (2) enhance cell proliferation from the periodontal ligament and supra-crestal area (Caffesse and colleagues, 1987b). The optimum concentration for use has been shown to be 0.38/mL saline (Smith and colleagues, 1987). Finally, FN has also been used as a substitute for sutures (Prato and colleagues, 1987) and is available in Europe as Tissucol, and Cortellin and colleagues (1991) achieved some positive effects in human infrabony defects.

Biomechanical Technique Recommendation

1. The teeth are first scaled and root planed for removal of
 - Calculus
 - Cementum
2. Biomechanical root preparation is completed either
 - Prior to the start of periodontal plastic procedures or
 - After complete débridement of the intra-bony defect

Note: Only EDTA will not coagulate flap and periosteal blood vessels and can be applied at any time.

3. CA and EDTA are applied on cotton pledgets for 2 minutes. TTC is applied as a paste for 2 to 5 minutes.
4. The pledgets are removed, and the root surface is profusely irrigated for 1 to 2 minutes.
5. If CA or TTC was used on bone, decertification is now carried out to open the blood vessels.

Conclusion

Root demineralization (CA, TTC) (Miller, 1983, 1985; Allen and Miller, 1989) is recommended for use in cosmetic gingival reconstruction prior to placement of bone implants (CA and TTC), in infrabony defects, as an implant additive (TTC) (Schallhorn and McClain, 1988; McClain and Schallhorn, 1993), and as a primary treatment for Class II furcations (CA) with or without bone implants.

It is important to note that in the *Annals of Periodontology*, Garrett, 1996; Mariotti 2003; American Academy of Periodontology, 2005), both the subject reviewer and the consensus report were in agreement that “the current use and application of citric acid, tetracycline or EDTA to modify the root surface provides no clinical benefit to the patient with respect to reduction of probing depths or gain in clinical attachment.”

CA root demineralization, although not fully supported by research on humans, does provide significant benefits that cannot be achieved by scaling and root planing alone. It ensures root detoxification, removal of the smear layer, and exposure of regeneration (Reynolds and colleagues, 2003). TTC may further increase these advantages. EDTA has the advantage of biocompatibility (pH 7.0). Both CA and TTC provide a surface substrate for future use of protein modifiers.

Note: Biomechanical root preparation has not been shown to have any negative effects but does have the potential to enhance and/or facilitate regeneration and should be considered as part of any clinical procedure requiring root detoxification.

In the future, periodontal regeneration will combine root detoxification with a combination of synthetic “biologic” protein modifiers that will artificially stimulate tissue regeneration. Amelogenins are but the first step in this process.



Cosmetic Gingival Reconstruction

Today, gingival reconstruction is not only possible, it is also a routine part of periodontal practice. The ability to cover unsightly exposed and sensitive roots and crown margins, to reconstruct lost ridges, and to enhance prosthetic reconstruction has undergone a rapid explosion.

This chapter deals exclusively with those procedures necessary for cosmetic and gingival enhancement:

1. Free gingival graft (FGG)
2. Coronally positioned flap
3. Subepithelial connective tissue graft (SCTG)
4. Pedicle flap
5. Semilunar flap
6. Transpositional flap
7. Connective tissue pedicle graft

Note: Pagliaro and colleagues (2004) and Clauser and colleagues (2004), in a review of the literature and a meta-analysis (1970–2000) of surgical treatment of recession, found it almost impossible to make comparative analysis of the procedures. They did find the following:

1. All procedures (SCTG, FGG, guided tissue regeneration, and laterally positioned flaps [LPF]) can achieve complete root coverage.
2. Complete root coverage was inversely proportional to the amount of recession.
3. All procedures were able to achieve high degree of complete root coverage when recession was shallow (1–2 mm).
4. The SCTG was superior to all other procedures when comparing complete root coverage with individual baseline recession of ≥ 2 mm.

Hwang and Wang (2006) and Boldi and colleagues found that the thicker the flap the greater the potential for root coverage. Pini-Prato and colleagues (2005) found that root coverage was significantly enhanced when flaps were positioned at or above the CEJ.

Grafting for Root Coverage

Historically, the free gingival autograft was not recommended for root coverage. Sullivan and Atkins (1968a, 1968b) and later Hall (1984) advocated that it be used only for gingival augmentation or prophylactically to increase the width of the zone of attached keratinized gingiva. These views were not surprising when one considers that the only published study on the subject of root coverage report-

ed only a 20% success rate (Mlinek, 1973). The major impediment to success was the large avascular area that the graft had to bridge and the lack of predictability that resulted from it.

From 1972 to 1982, individual case reports of successful results were reported (Hawley and Staffilino, 1970; Ward, 1974; Livingston, 1975), but it was Miller (1982, 1985b) who, modifying the basic grafting techniques, was able to demonstrate that successful root coverage was not only attainable but also predictable over denuded root surfaces even if they were of the Class II deep-wide variety. This was followed in rapid succession by others (Holbrook and Ochsenbein, 1983; Ibbott and colleagues, 1985; Bertrand and Dunlap, 1988; Borghetti and Gardella, 1990; Tolmie, 1991), all of whom were able to show that successful root coverage was not only attainable but also predictable.

Etiology of Gingival Recession

There is little or no research on the developmental progression of gingival recession except for the classic study by Baker and Seymour (1976). They classified four distinct stages in the development of recession (Figure 21-1):

1. Normal or subclinical inflammation
2. Clinical inflammation and proliferation of epithelial rete pegs
3. Increased epithelial proliferation, resulting in the loss of the connective tissue core
4. Merging of the epithelium, resulting in separation and recession of the gingival tissues

Classification of Gingival Recession

Sullivan and Atkins (1968a) classified gingival recession into four categories: deep-wide, shallow-wide, deep-narrow, and shallow-narrow. Of these, they felt that the deep-wide gingival recession was the most difficult to treat and offered the least predictability for attaining root coverage. Miller (1985b) expanded this classification for gingival recession to take into account the nature and quality of gingival recession and its relationship to the adjacent interproximal tissue height.

Miller Classification

Class I: Shallow-narrow and shallow-wide gingival recession in which the marginal tissues have not receded beyond

the mucogingival junction. There is no loss of interproximal soft tissue or bone. One hundred percent root coverage is possible (Figure 21-2A).

Class II: Deep-narrow and deep-wide gingival recession in which the marginal tissues have receded beyond the mucogingival junction. There is no loss of interproximal soft tissue or bone. One hundred percent root coverage is possible (Figure 21-2B).

Class III: Class I or II of interproximal bone such that the soft tissue is now apical to the cemento-enamel interproximal junction but coronal to the marginal tissue. One hundred percent root coverage is not possible (Figure 21-2C).

Class IV: The loss of interproximal bone and soft tissue is such that one or both of the adjacent interdental areas are level with the marginal gingiva. No root coverage is possible (Figure 21-2D).

Procedural Modifications

Preparation of the recipient and donor sites for the free soft tissue graft for root coverage is shown in Figure 21-3. Certain modifications of principles or techniques that enhance success are needed when the recipient and donor sites are prepared (see Figure 21-3A):

1. Scaling and root planing are carried out to remove soft cementum, calculus, and plaque and to reduce the prominence of root convexities. Fine enamel finishing burs may be used to help flatten the root in the cervical third.
2. Citric acid (pH 10) is applied with a small cotton pledget and burnished in for 3 to 5 minutes (Miller, 1982). This promotes root demineralization, detoxification of the root surface, opening of the dentinal tubules, and exposure of the connective tissue root fibers. This process has been shown to prevent apical migration of epithelium, to promote palate activation, to increase clot stability, and to enhance attachment by linkage (see Chapter 20, "Biomechanical Root Preparation").
3. The horizontal papillary incisions are made at right angles to the papilla above the level of the cemento-enamel junction (CEJ) to create a butt joint. When butt joints cannot be achieved, all of the epithelium over the

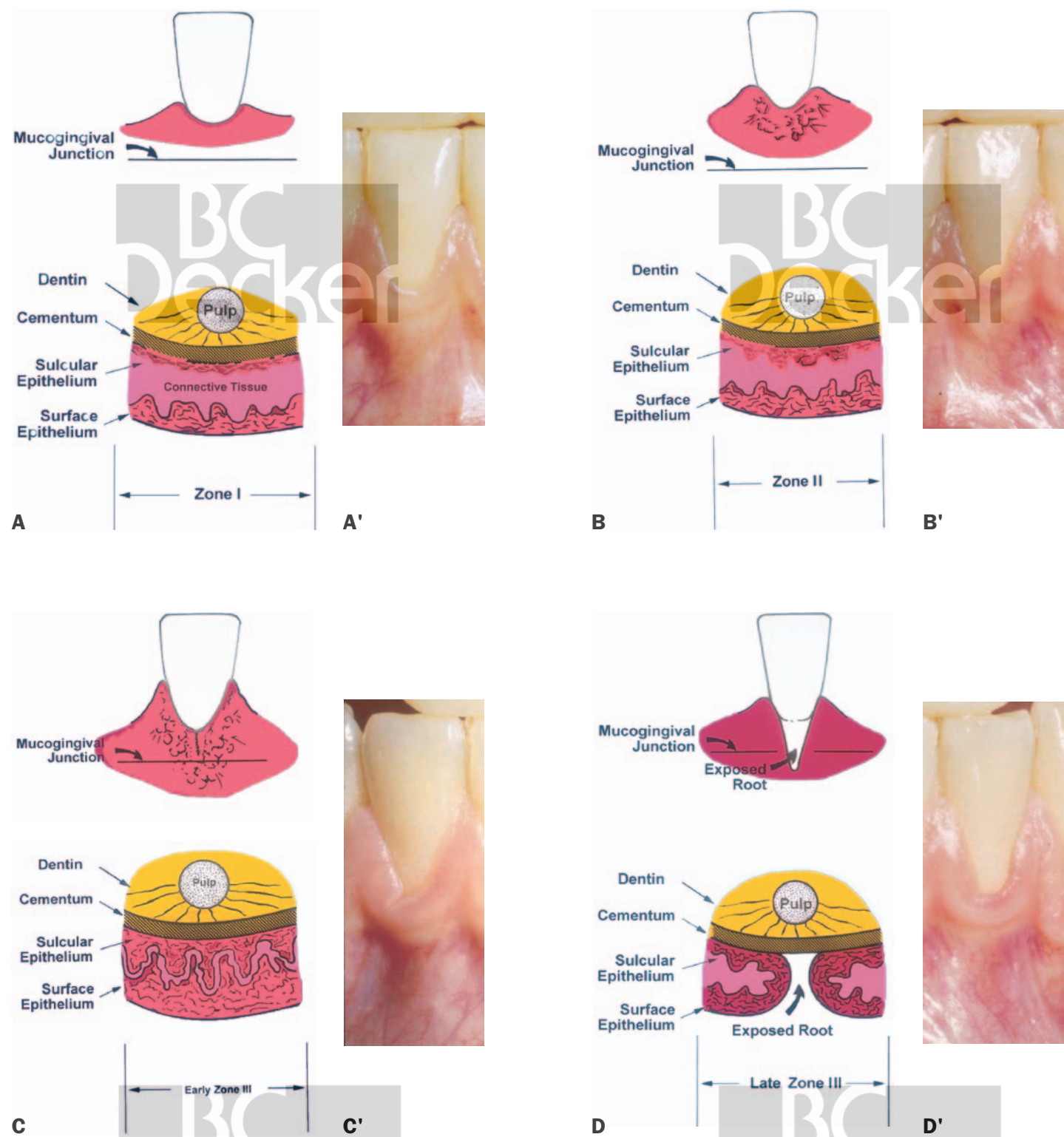


FIGURE 21-1. Etiology of gingival recession. A, A', Normal tissue. B, B' Inflamed tissue with epithelial proliferation. C, C', Epithelial tissue beginning to merge forming a line due to lack of connective tissue core. D, D', Epithelial tissue merge and form separation of recession.



FIGURE 21-2. Classification of gingival recession. *A* and *A'*, Class I. *B* and *B'*, Class II. *C* and *C'*, Class III. *D* and *D'*, Class IV.



FIGURE 21-3. Free soft tissue graft for root coverage. *A* and *A'*, Before surgery; note clinical gingival recession of the cuspid and bicuspid. *B*, Periosteal bed prepared by sharp dissection. *C* and *C'*, Periosteal bed preparation completed. *D* and *D'*, The graft is first tacked into position by interrupted sutures. *E* and *E'*, Modified suturing technique for improved graft stability. *F*, Eight months later.

papilla is removed to enhance bleeding and provide a connective tissue bed for graft contact (see Figure 21-3B).

4. The periosteal bed should be extended mesially, distally, and apically for about 4 to 6 mm on all sides of the denuded root to permit adequate graft extension (see Figure 21-3C).
5. Any epithelial remnants adjacent to the root should be removed.
6. A thick graft of 1.5 to 2.5 mm is preferred (Miller, 1982) (see Figure 21-3, D and D'). Because of the size and thickness of the grafts required for root coverage, it is sometimes advantageous to fabricate a palatal stent for protection and comfort during healing (Figure 21-4D and E).
7. The graft should be of uniform thickness, with no beveled margins. All margins should be at right angles to the graft surface (Holbrook and Ochsenbein, 1983).
8. The graft, when placed at or slightly above the CEJ of the denuded root, should extend

sufficiently to overlap the periosteal bed mesially, distally, and apically for 3 to 4 mm to ensure adequate plasmatic diffusion (see Figure 21-3, D and D').

9. Tracking sutures are used for initial graft stabilization prior to suture modification (see Figure 21-3, D and D').
10. The specialized suturing is now completed (see Figure 21-3, E and E').
11. The final result is seen in Figure 21-3F.

The clinical procedures are depicted in Figures 21-4 to 21-6.

Suturing Modification for Root Coverage

Carvalho (1972) and Holbrook and Ochsenbein (1983) noted that when grafts are used for root coverage and underlying anatomic osseous factors must be taken into account, the teeth with the most prominent roots generally exhibit the least amount of bone over them, the most dehiscences and fenestrations, the greatest gingival scalloping,

the thinnest type of periodontium, the most esthetic form, and the most mucogingival problems. They pointed out that prominent, bulging roots produce deep interproximal valleys (Figure 21-7), which require close adaptation of the grafts. These interradicular concavities necessitate graft stabilization to promote intimate graft contact and prevent dead space and hematoma formation.

Procedure

1. The first suture is a horizontal "graft stretching" suture, which Sullivan and Atkins (1968a) noted was to counteract the primary contraction and open the blood vessels within the graft (Figure 21-8A). The graft is usually stretched 2 to 3 mm.
2. The second suture is a circumferential suture, which holds the graft against the denuded areas (Figure 21-8B).
3. The third suture, the interdental concavity suture, prevents dead space formation in the interradicular concavities or depressions (Figure 21-8C).

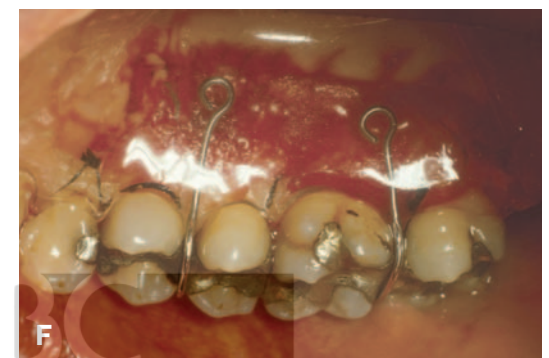
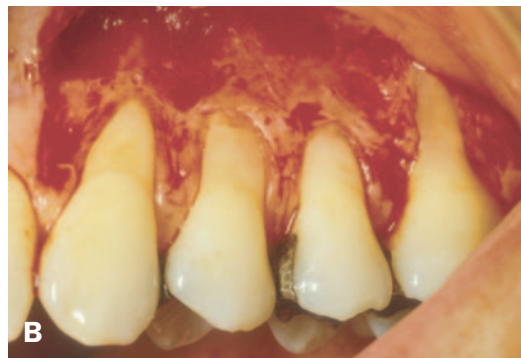


FIGURE 21-4. Free soft tissue graft for root coverage. A, Before treatment, showing multiple areas of recession. B, Mucosal flap reflected, showing significant Class II deep-wide gingival recession. C, Deep-wide gingival graft removed from the palate. Palate sutured with chromic gut sutures for hemostasis. D and E, Palatal stent that was fabricated to protect the palate. F, Stent positioned on the palate. G, Free gingival graft positioned and sutured. H, Two years later; note the excellent result and complete root coverage. Compare with A and B.



FIGURE 21-5. Free soft tissue graft for root coverage. *A* and *A'*, Before treatment. *B* and *B'*, Biomechanical root preparation with citric acid. *C* and *C'*, Graft placed over the large Class II deep-wide recession and sutured. *D* and *D'*, One year later; note complete root coverage.



FIGURE 21-6. Free soft tissue autograft for root coverage. *A* and *A'*, Before treatment showing prominent frenum. *B* and *B'*, Periosteal bed prepared; note adequate extension mesially, distally, and apically. *C* and *C'*, Full-thickness graft placed. *D* and *D'*, Seven months later; total coverage is achieved.



FIGURE 21-7. Dry skull composite representation of a prominent root with deep interproximal concavities. Side view and facial view. Note cuspid prominence dehiscence.

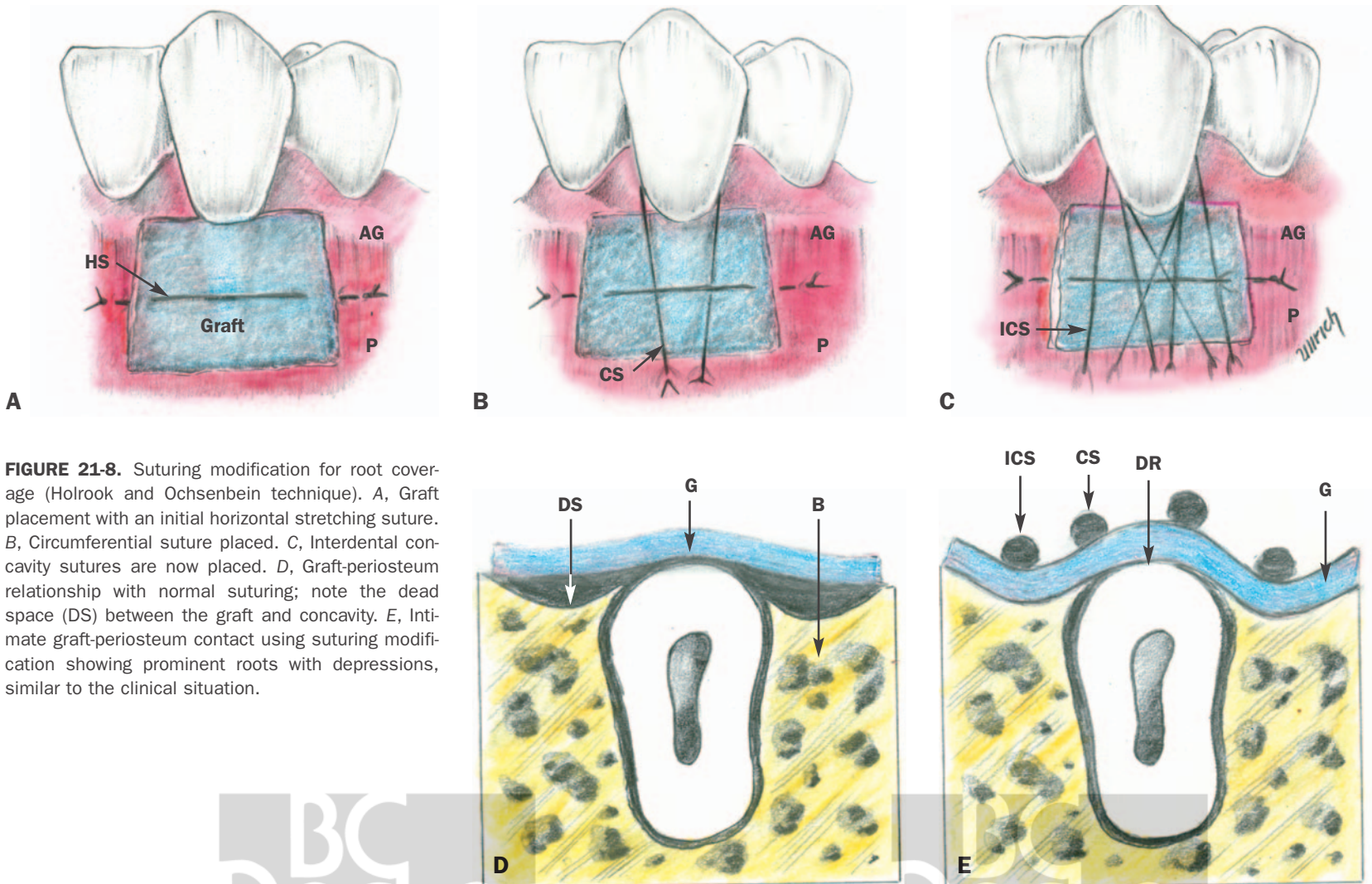


FIGURE 21-8. Suturing modification for root coverage (Holbrook and Ochsenbein technique). A, Graft placement with an initial horizontal stretching suture. B, Circumferential suture placed. C, Interdental concavity sutures are now placed. D, Graft-periosteum relationship with normal suturing; note the dead space (DS) between the graft and concavity. E, Intimate graft-periosteum contact using suturing modification showing prominent roots with depressions, similar to the clinical situation.

4. Figure 21-8D is a cross-sectional view showing the dead space resulting when routine suturing techniques are used. Figure 21-8E is a cross section depicting the intimate contact between the graft and the underlying periosteal bed when the proper suturing technique is employed.

This procedure is shown clinically in Figures 21-3, 21-6, and 21-9.

Creeping Attachment

Goldman and colleagues (1964) and Matter (1976, 1980) noted a second mechanism of gaining root coverage by the phenomenon of creeping attachment. This occurred between 1 month and 1 year and was the result of the coronal migration of the newly grafted attached gingiva. The amount of anticipated coverage was totally unpredictable (see Figure 21-9).

Coronally Positioned Flap

The coronally positioned flap has long been used as a means of gaining root coverage. This technique has met with varying degrees of success owing to minimal amounts of keratinized gingiva. It was not until 1965, when Harvey published the results of his combined technique, which used a first-stage FGG to enhance the mucogingival complex and then coronally repositioned it in the second stage, that the technique received much attention. Bernimoulin (1975) graphically outlined the combined procedure as it is used in practice today. The combined procedure is used only when there is an inadequate zone of keratinized gingiva.

Allen and Miller (1989) used this procedure and were able to achieve 3.18 mm root coverage (97.8%) of shallow marginal recession. They used citric acid in combination with a partial-thickness pedicle flap that was coronally positioned.

Indications

1. Esthetic coverage of exposed roots
2. For tooth sensitivity owing to gingival recession

Requirements

The main prerequisite is an adequate zone of keratinized gingiva (≥ 3 mm).

Advantages

1. Treatment of multiple areas of root exposure
2. No need for involvement of adjacent teeth
3. High degree of success
4. Even if the procedure does not work, it does not increase the existing problem

Disadvantage

The main disadvantage is the need for two surgical procedures if the zone of the keratinized gingiva is inadequate.

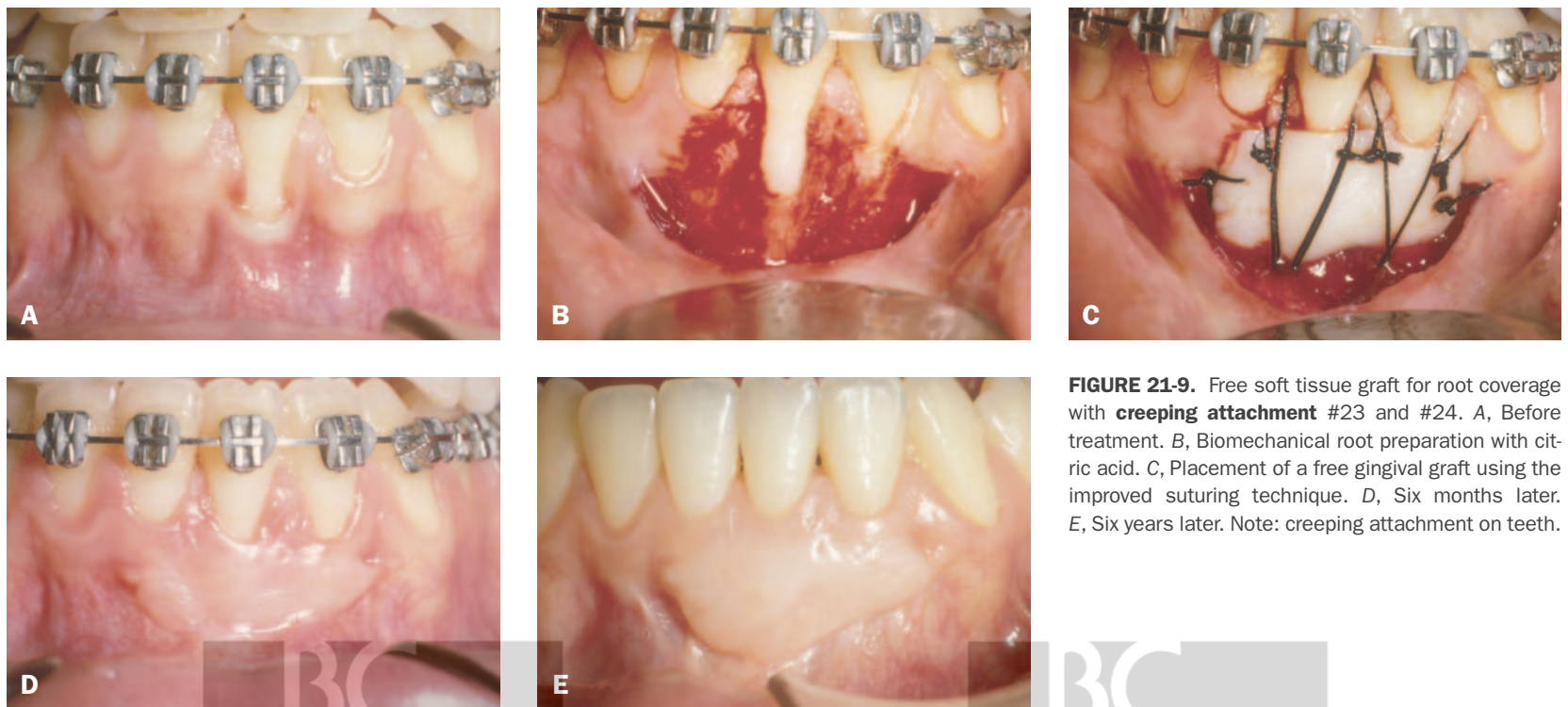


FIGURE 21-9. Free soft tissue graft for root coverage with **creeping attachment** #23 and #24. A, Before treatment. B, Biomechanical root preparation with citric acid. C, Placement of a free gingival graft using the improved suturing technique. D, Six months later. E, Six years later. Note: creeping attachment on teeth.

Procedure

In Figure 21-10, A and A' display the common findings of a prominent cuspid with recession. The probable causes of the recession are the position of other teeth, prominent root convexity, orthodontic restoration, toothbrush abrasion, frenulum pull, or thin alveolar housing.

With the patient under anesthesia, the exposed root is scaled and root planed to remove softened cementum and reduce or eliminate prominent root convexities. Citric acid (pH 1.0) is burnished in with a moistened cotton pledget for 3 to 5 minutes.

A full-thickness flap is raised (Figure 21-10, B and B') using two parallel vertical incisions to outline the surgical area. The incisions border the papillae that are to be moved coronally. A scalloped, inverse-beveled incision is made using a no. 15 scalpel blade to connect the two vertical incisions. The scalloped incision is made at the gingival crest facially, but interproximally, care is taken to create new papillae that will fit their future locations. The remaining portion of the papillae will undergo epithelial denudation with small ophthalmic scissors or tissue nippers.

The flap is positioned (Figures 21-10C and C') 1 mm coronal to the CEJ. To facilitate coronal movement, the base of the flap is undermined and separated from the periosteum with scissors.

The flap is sutured coronally with a sling-type papillary suture around the neck of the tooth. This positions and stabilizes the flap coronally. Interrupted sutures are used laterally. Figure 21-10D' shows the completed case. See also Figure 21-11. Clinical cases are depicted in Figures 21-12 to 21-14.

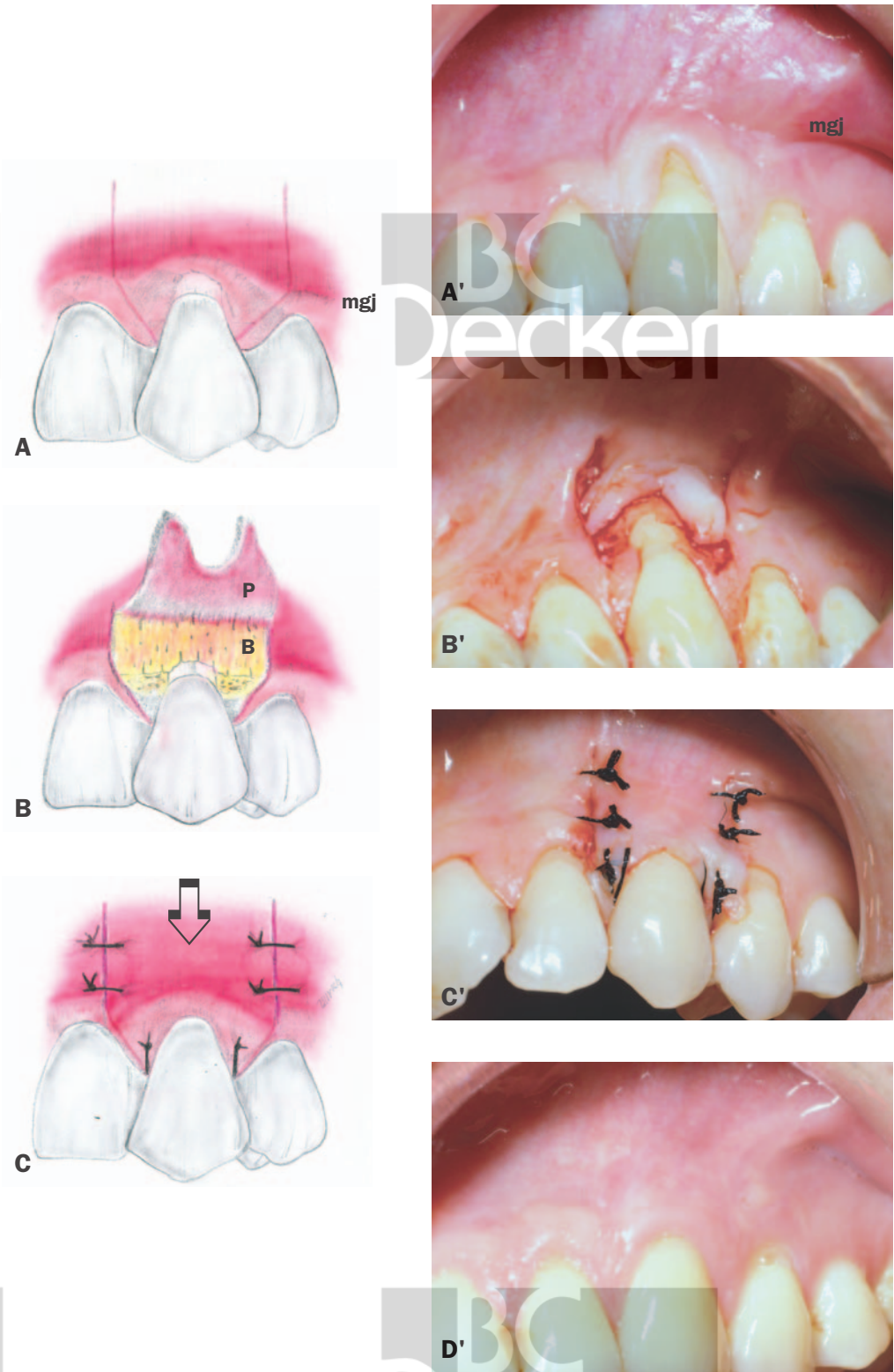


FIGURE 21-10. Coronally positioned pedicle flap, diagrammatic view. A, Incisions outlined preoperatively. Note that the incisions do not go to the tips of the papillae. B, A full-thickness flap is reflected, exposing the underlying bone (B). The epithelium overlying the remaining portion of the papillae (P) is removed. C, The flap is sutured coronally for root coverage. Clinical view: A', Before. B', Full-thickness flap reflected. C', Epithelium over the remaining papillae removed and the flap sutured coronally. D', Two years later; compare with A'.

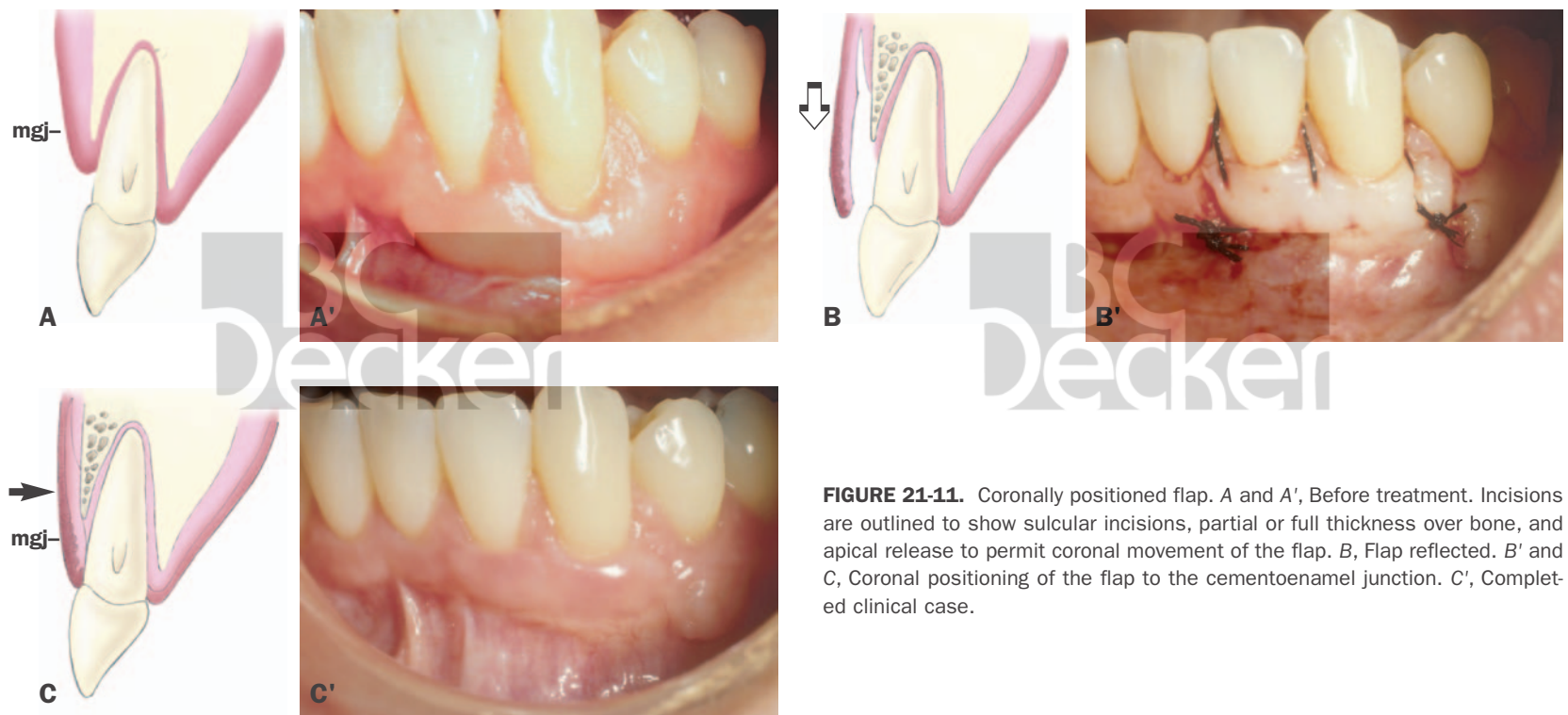


FIGURE 21-11. Coronally positioned flap. A and A', Before treatment. Incisions are outlined to show sulcular incisions, partial or full thickness over bone, and apical release to permit coronal movement of the flap. B, Flap reflected. B' and C, Coronal positioning of the flap to the cemento enamel junction. C', Completed clinical case.

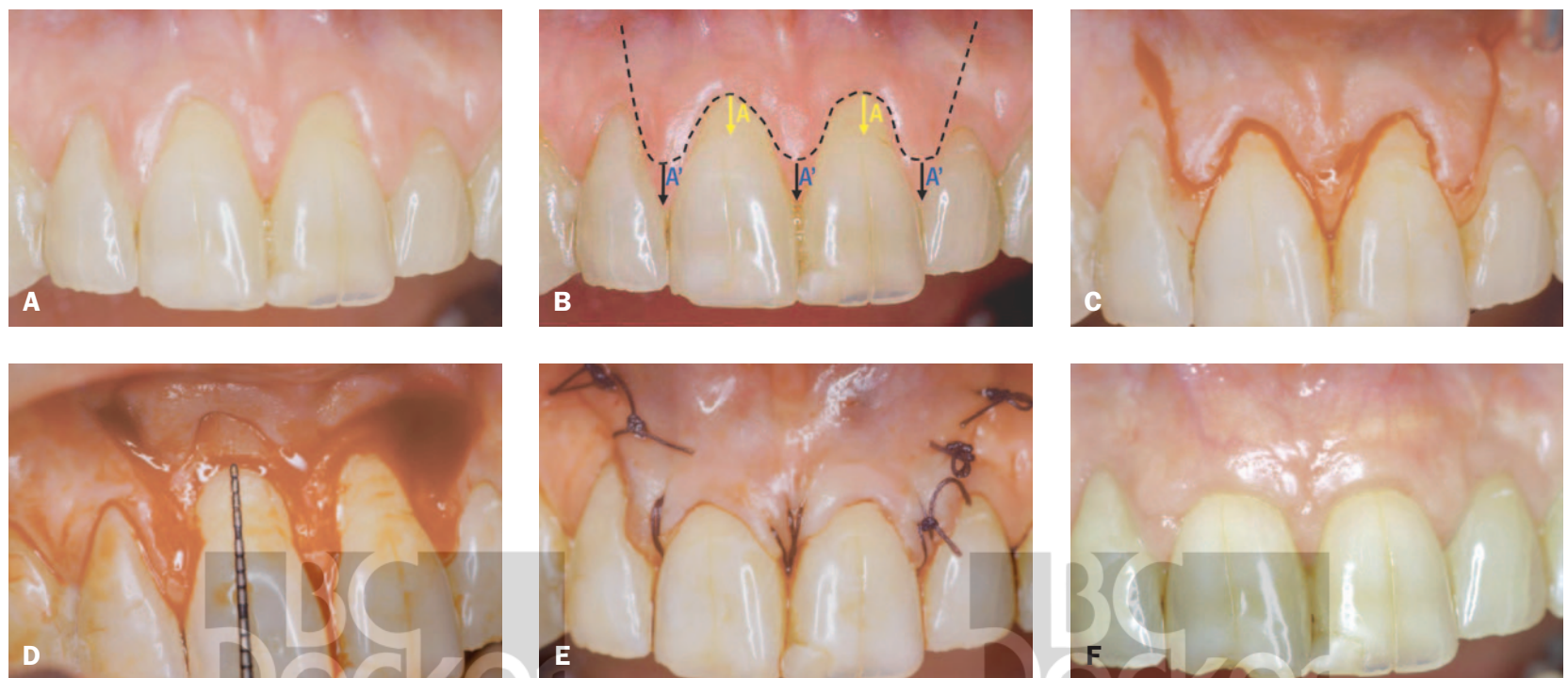


FIGURE 21-12. Coronally positioned flap. Technique. A, Initial view with unsightly recession on teeth 8 and 9. B, Outline of incisions. Arrows indicate that the distance of the recession (A) is equal to the height of the recession in the papilla (A'). C, Incisions completed. D, Flap reflected showing hidden recession. E, 5-0 vicryl sutures. F, Final result. Compare to Figure A.

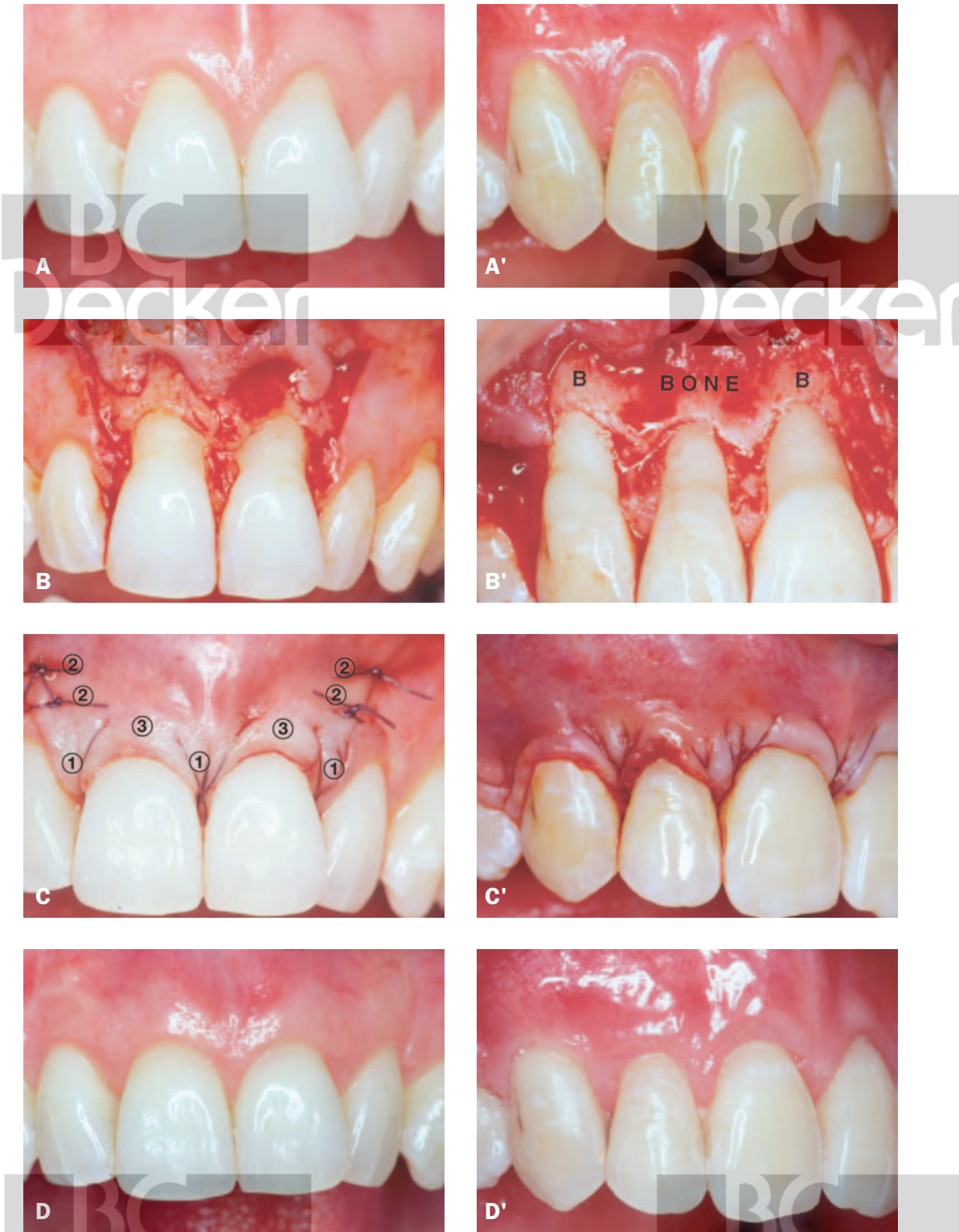


FIGURE 21-13. Coronally positioned flap. A, A', Initial views showing significant gingival recession. B, B', Full thickness flaps reflected with significant additional recession. C, C', Suspensory (1, papillary: 3, facial) and interrupted (2, lateral periosteal stabilizing sutures) sutures for stabilization. D, D', Final results.



FIGURE 21-14. Coronally positioned flap on teeth. *A, A'*, Initial views right and left. Note cervical abrasion. *B, B'*, Flap reflected and full extent of recession demonstrated. *C, C'*, Flap coronally positioned and sutured. *D, D'*, Final result. Compare to Figures *A, B*.

Subepithelial Connective Tissue Graft

This procedure is the single most effective way to achieve predictable root coverage with a high degree of cosmetic enhancement.

History

Historically, the underlying gingival connective tissue has been shown to be a viable source of cells for repopulating the epithelium (Karring and colleagues, 1971) and a somewhat predictable source for increasing the zone of keratinized gingiva (Edel, 1974; Becker and Becker, 1986).

Langer and Langer (1985) published an article that introduced and outlined the indications and procedures necessary for achieving success with the SCTG. Nelson (1987) modified the procedure somewhat to further enhance clinical predictability ($\geq 90\%$).

The technique gains its clinical predictability by use of a bilaminar flap (Nelson 1987; Harris, 1992) design to ensure graft vascularity and a high degree of gingival cosmetics from the secondary intention healing of the connective tissue graft. This seems to avoid the “tire patch” look often associated with FGGs. Jahnke and colleagues (1993) in comparing FGG to SCTGs, found the connective tissue graft to be significantly ($p < .03$) more effective than the FGG.

Indications

1. Esthetics
2. Predictability
3. One-step procedure
4. Minimum palatal trauma
5. Can treat multiple teeth
6. Increased graft vascularity

Disadvantages

1. High degree of technical skill required
2. Complicated suturing

Contraindications

1. Broad, shallow palates where contact with the palatal artery may be anticipated
2. Excessively glandular or fatty palatal submucosa

Procedure

The procedure is basically a combination of a partial-thickness coronally positioned flap and a free connective tissue graft.

Recipient Site

1. The root surface is scaled and root planed to flatten prominent convexities and to remove any softened root structure, endotoxins, and composite restorations. Enamel finishing burs may be used to help flatten the root

convexity in the central portion of the root or after removal of composite restorations.

2. Use of the chemical root modifiers citric acid (pH 1.0 for 3 to 5 minutes) tetracycline (3 to 5 minutes), or ethylenediaminetetraacetic acid (EDTA) (pH 7.0) is optional.
3. A no. 15 scalpel is used to outline the surgical site, making sure to raise a partial-thickness flap (no incisions are made down to bone).

The scalloped papillary incisions must be made above the CEJ to assume total root coverage and so that an adequate bleeding surface is prepared (Figure 21-15, A and B).

4. Two vertical incisions are extended adequately into the mucosal tissues to permit coronal positioning of the flap. The partial-thickness flap is raised by sharp dissection (Figure 21-15C).

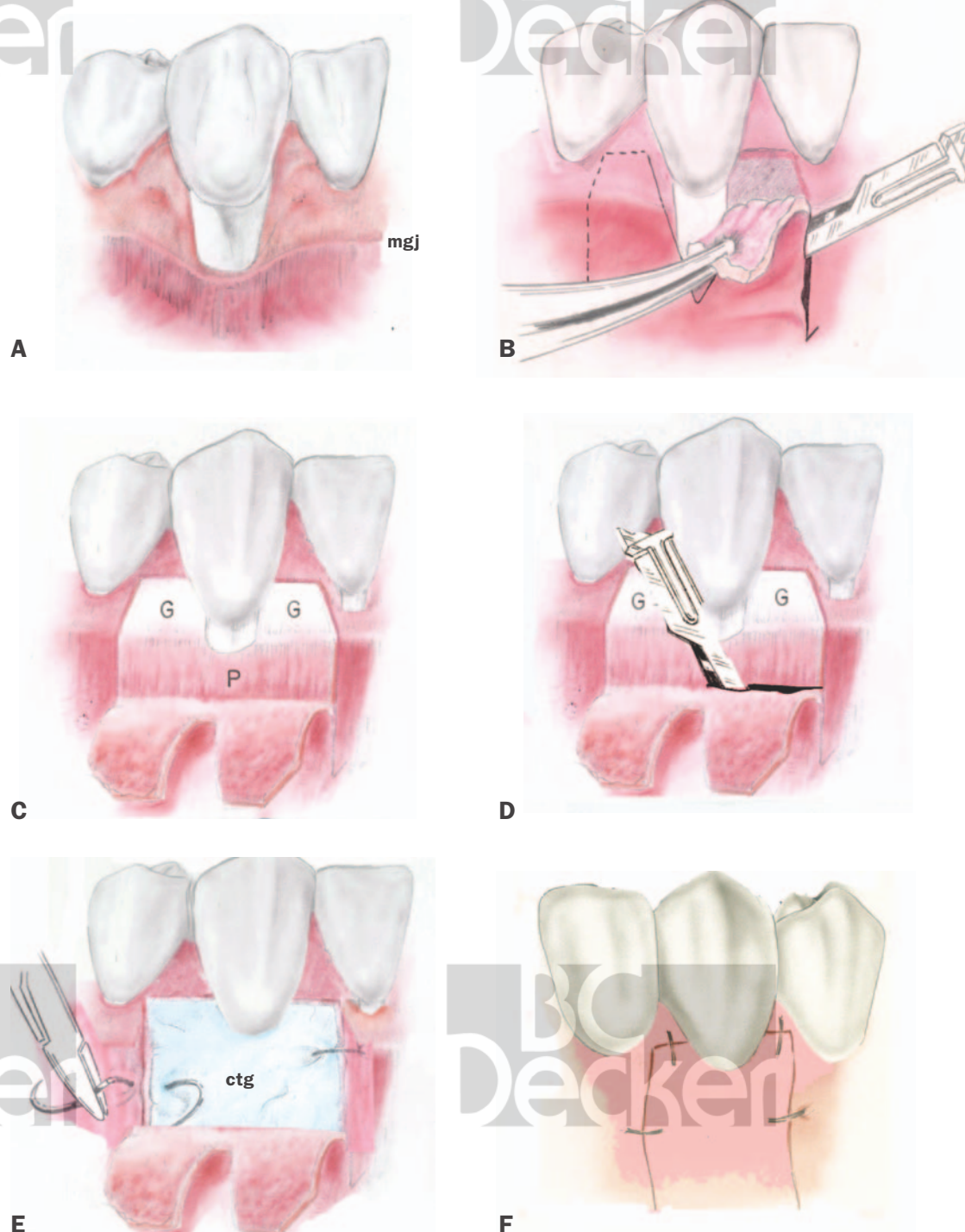


FIGURE 21-15. Subepithelial connective tissue graft: recipient site. A, Before treatment. B, Partial-thickness pedicle flap reflected by sharp dissection. C, Partial-thickness pedicle flap is reflected. D, The apical border of the pedicle flap is released to permit coronal repositioning. E, Connective tissue graft positioned and sutured with epithelium positioned onto the enamel. F, Flap coronally positioned and sutured.

5. Apically, the undersurface of the flap is released from the underlying periosteum via a horizontal incision. This will permit coronal positioning of the flap (Figure 21-15D).
4. To completely free the graft, a horizontal incision is made at its most apical border (Figure 21-16, D and D').
5. On removal, the graft is placed on a saline-moistened gauze sponge (Figure 21-16, E and E').

Donor Site

Unlike the FGG, the connective tissue graft is taken internally and is not limited by rugae.

1. A straight, horizontal incision is begun approximately 5 to 6 mm from the free gingival margin with a no. 15 scalpel blade. The incision is begun in the molar areas and extended anteriorly. The blade is used to undermine a partial-thickness palatal flap (Figure 21-16, A and A').

Note: The length and width of the partial-thickness palatal flap will vary with the size of exposed root to be covered.

It is also important to note that if additional graft length is required, the incisions may be carried anteriorly into the rugae area because the connective tissue graft is not adversely affected by the rugae.

2. A second, more coronally positioned parallel incision is now made approximately 3 mm from the gingival margin with a no. 15 blade. It is continued apically to the same level as the first incision. The blade may have to be angled toward the bone to ensure adequate graft thickness (Figure 21-16, B and B').

Note: This second incision will produce a connective tissue wedge with a 2 to 3 mm-wide epithelial border and is 1.5 to 2 mm in thickness.

3. Vertical incisions (optional) are used for graft release mesially and distally. They are made from the outer epithelial surface down through the submucosa. This will free the terminal ends of the graft (Figure 21-16, C and C').

Note: The use of vertical incision is optional.

If vertical incisions are not used (envelope technique modification), the flap is extended one to two teeth anterior and posterior to the affected area. This will permit adequate drape of the tissue and space for graft placement and is a simple, effective treatment and an excellent alternative to vertical incisions.

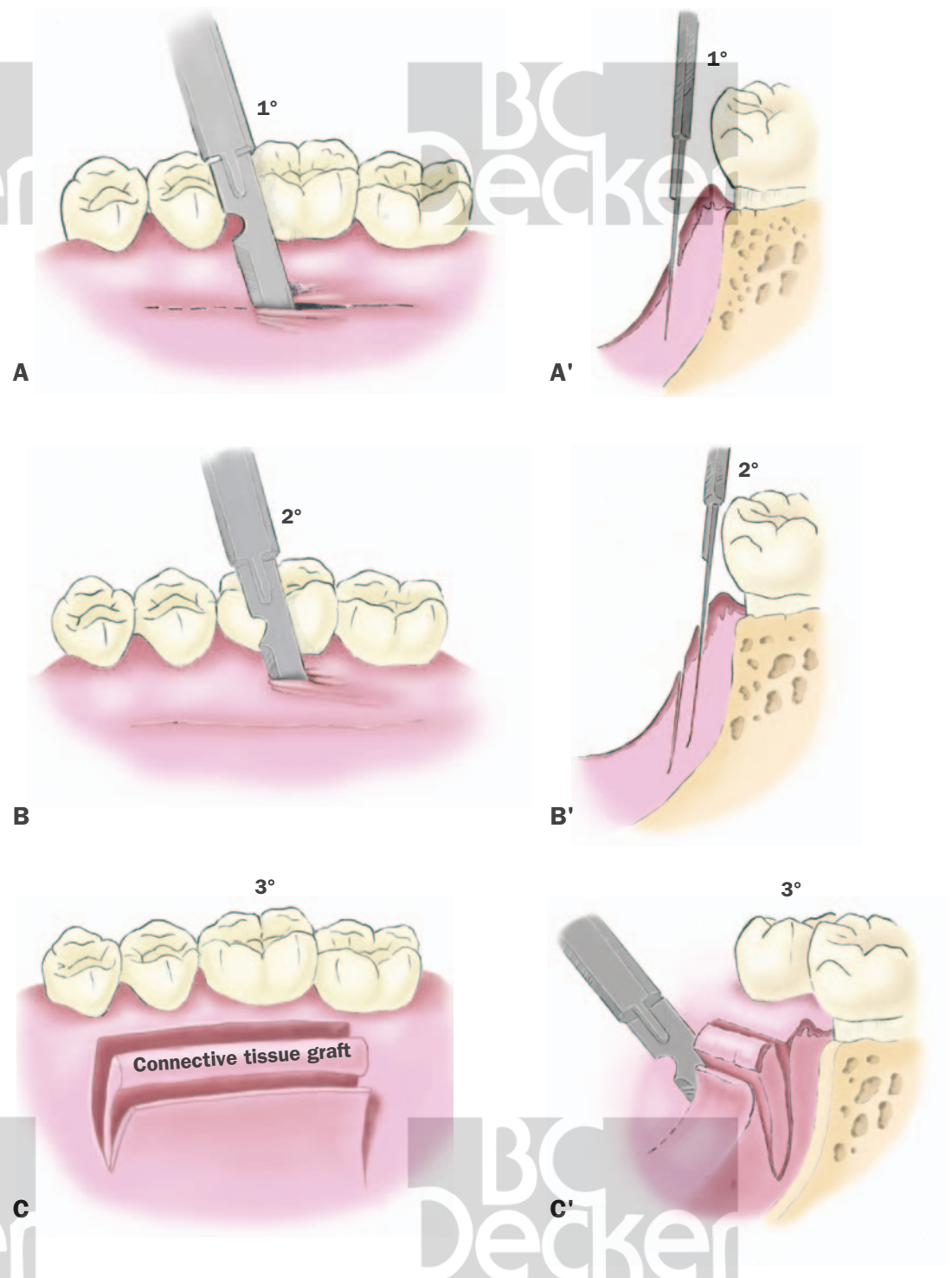


FIGURE 21-16. Subepithelial connective tissue graft: donor site (palatal and cross sectional views). A and A', Primary horizontal partial-thickness incision begun 5 to 7 mm from free gingival margin. B and B', Secondary horizontal incision made 2 to 3 mm from gingival margin. Incisions are directed apically to provide a connective tissue graft 1.5 to 2 mm in thickness and a length sufficient to cover the exposed root surface to be covered. C and C', Optional vertical incisions are made at the terminal ends of the graft.

6. The palate is now sutured with a combination of horizontal mattress sutures or continuous basting sutures. Immediate suturing will promote hemostasis and prevent excessive clot formation (Figure 21-16, F and F').

Monnet-Corti and colleagues (2006) found that in the maxillary bicuspid area, regardless of vault size, it was always (100%) possible to take a 5-mm wide CT graft and 8-mm, 93% of the time.

The clinical procedure of donor site management is depicted in Figure 21-17.

Graft Placement

1. The graft is trimmed to size with a sharp scissors or no. 15 blade. There is no need for complete removal of glandular or fatty tissue.
2. The graft is placed so that the epithelial border is positioned above the CEJ and onto the enamel. This will ensure greater root coverage, predictability, and enhanced esthetics (see Figure 21-15E).
3. Intimate graft-root contact is achieved by first stabilizing the graft laterally with interrupted sutures and then by using a continuous sling suture about the necks of the teeth for cervical positioning and stabilization. To avoid problems of retrieval, chromic gut sutures are recommended for graft positioning and stabilization (see Figure 21-15E).

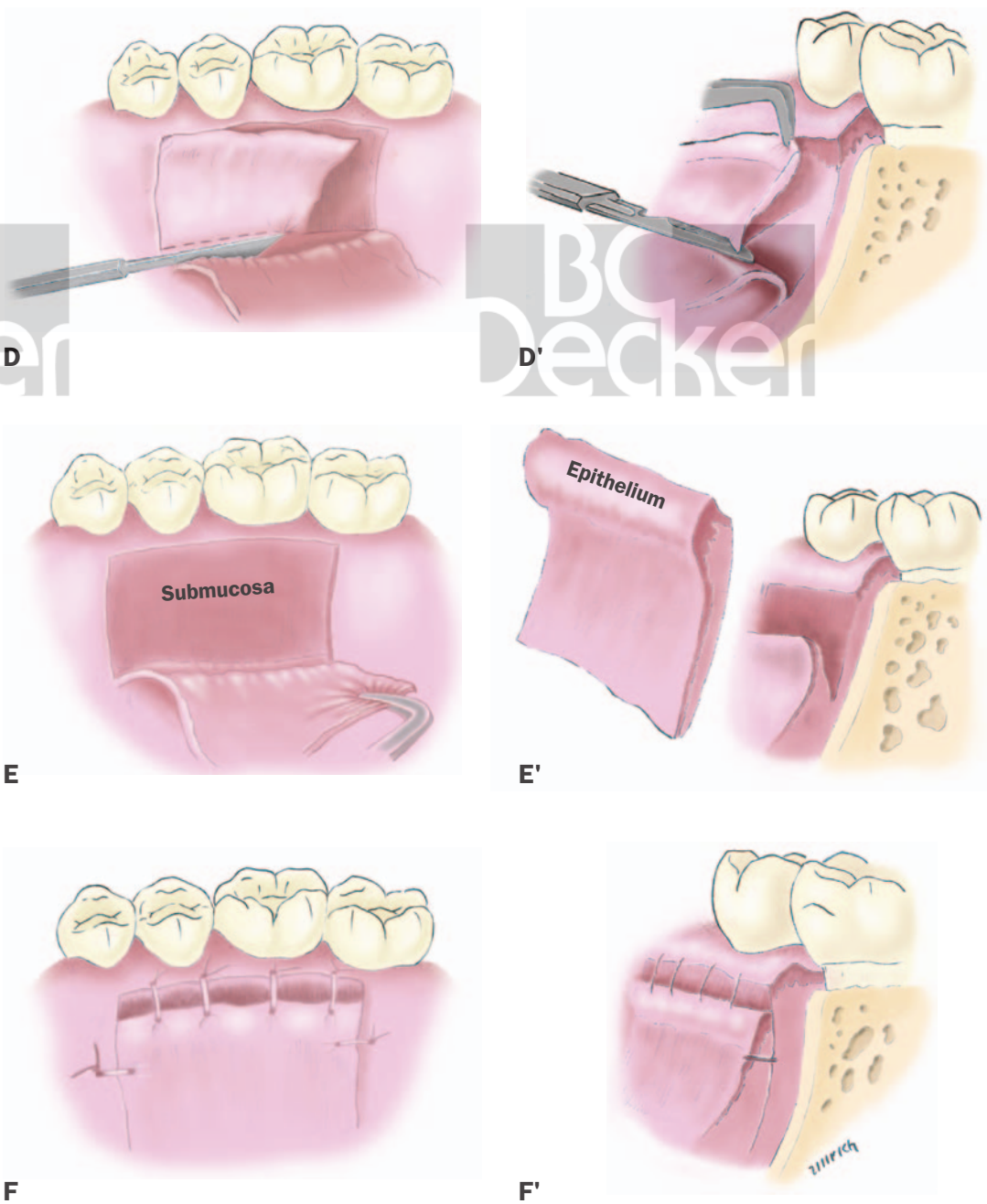


FIGURE 21-16. Continued. *D* and *D'*, The primary flap is reflected. With the graft held in a tissue forceps, it is released apically with a sharp horizontal incision. *E* and *E'*, The subepithelial graft is removed and the underlying submucosa exposed. *F* and *F'*, Primary flap sutured with almost complete coverage obtained. Suturing can be interrupted, continuous, or suspensory.

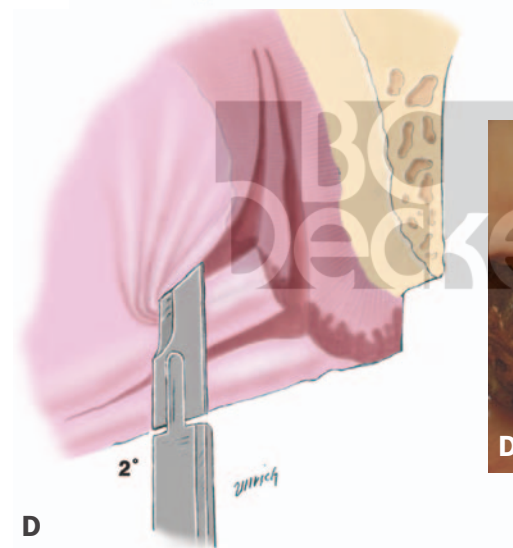
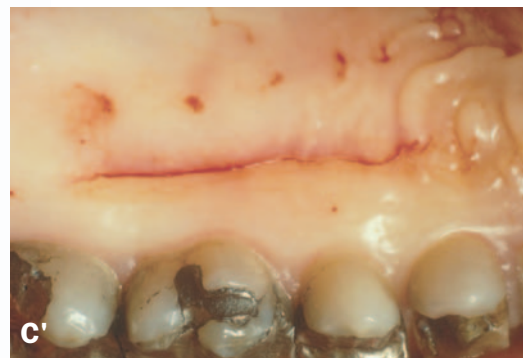
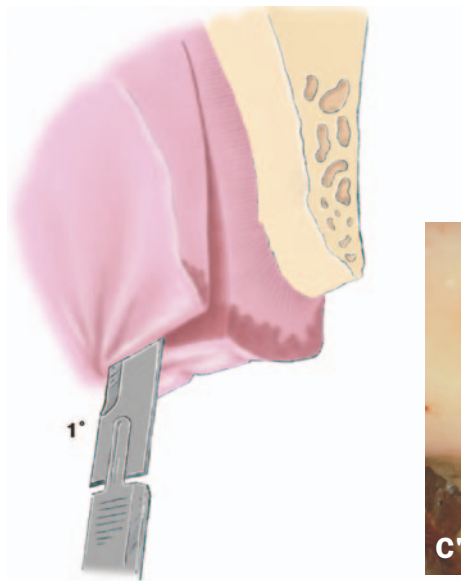
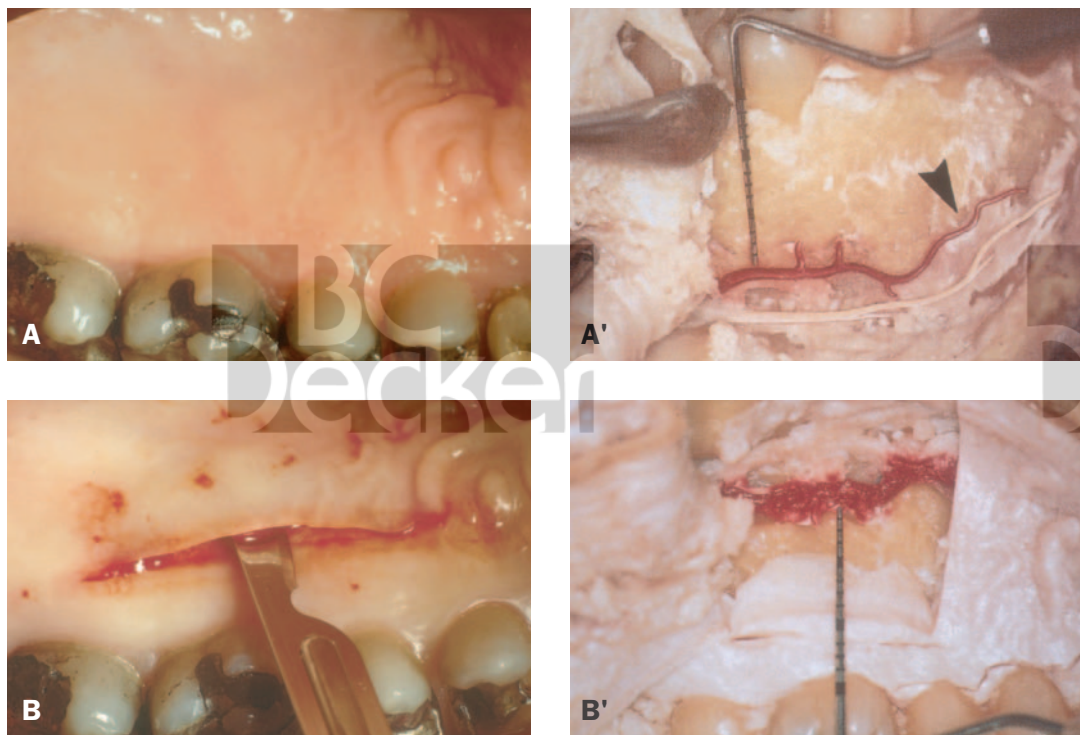


FIGURE 21-17. Part I. Trap door. **A** and **A'**, Preoperative view. Underlying course of palatal artery. Notice upward rise of palatal artery in lateral area. **B** and **B'**, Initial graft incision seen. Note the close proximity to terminal end of palatal artery. **C** and **C'**, 1° Horizontal incision being made. **D** and **D'**, 2° Horizontal incision being made. **E**, Vertical releasing incisions outlined. Note the vertical incisions are optional.

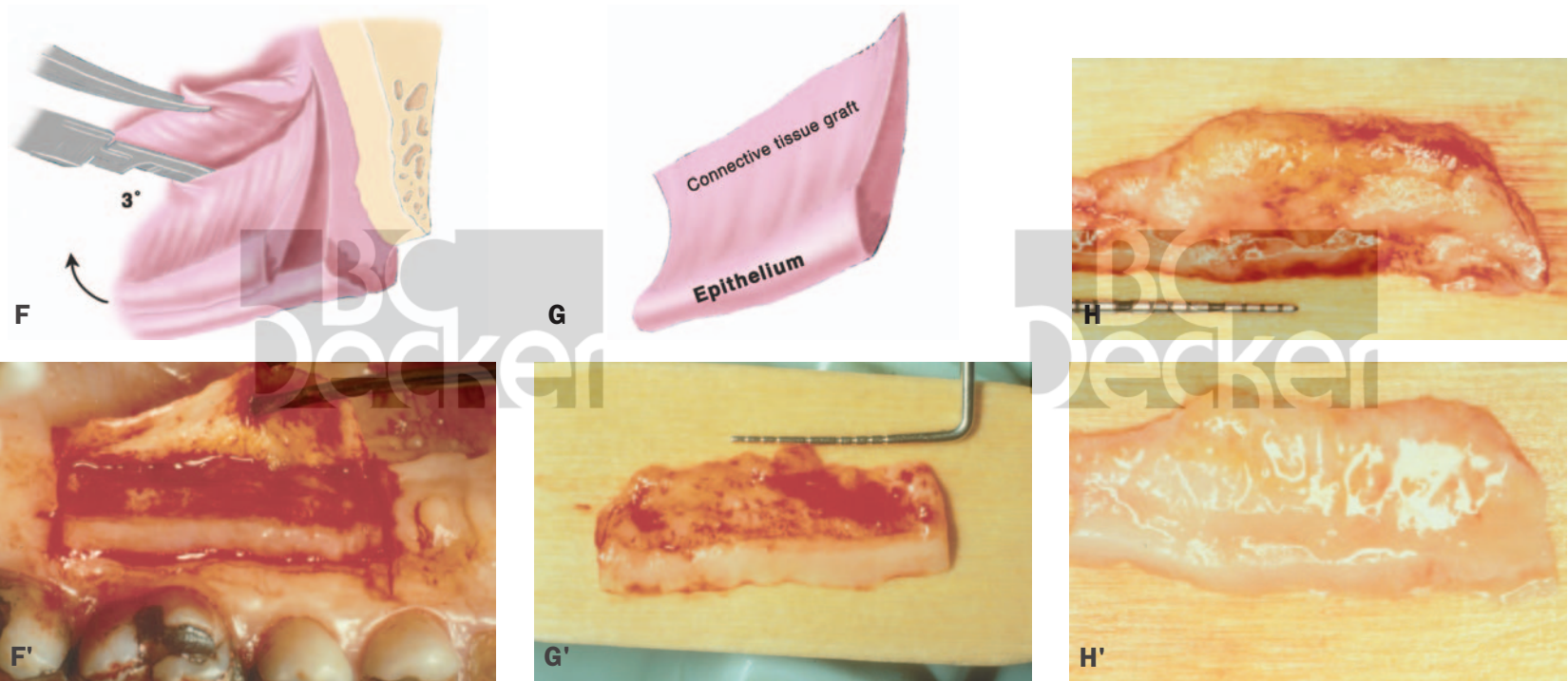


FIGURE 21-17. Part I. Continued. *F* and *F'* Apical horizontal releasing incision is made for graft release. *G* and *G'*, Connective tissue graft is freed. *H* and *H'*, the graft is trimmed to size, shape, and contour. *I*, Submucosa after graft removal. *J*, Primary flap sutured with horizontal basting incision. (Anatomical slides *A'* and *B'* were contributed by Dr. Roger Wise, Swampscott, MA and reproduced with permission of Quintessence Publishing Co.)

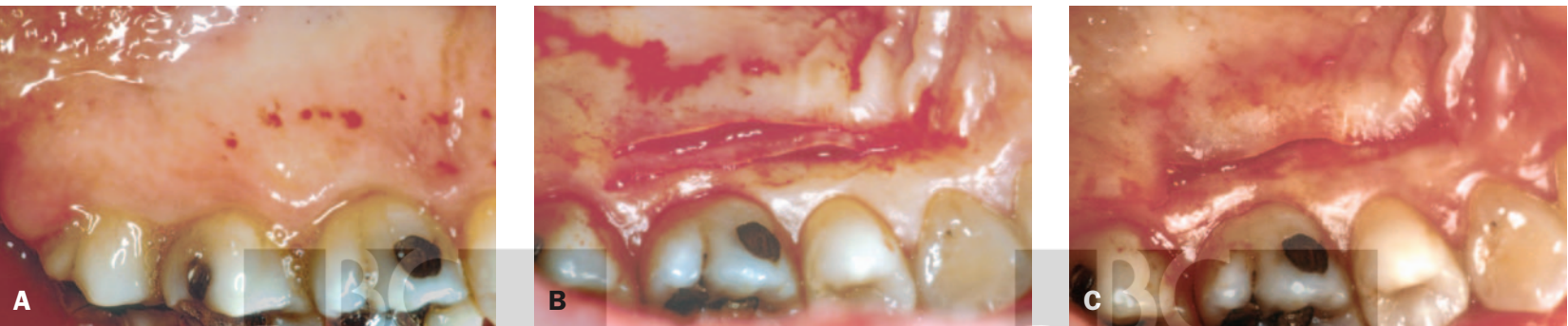
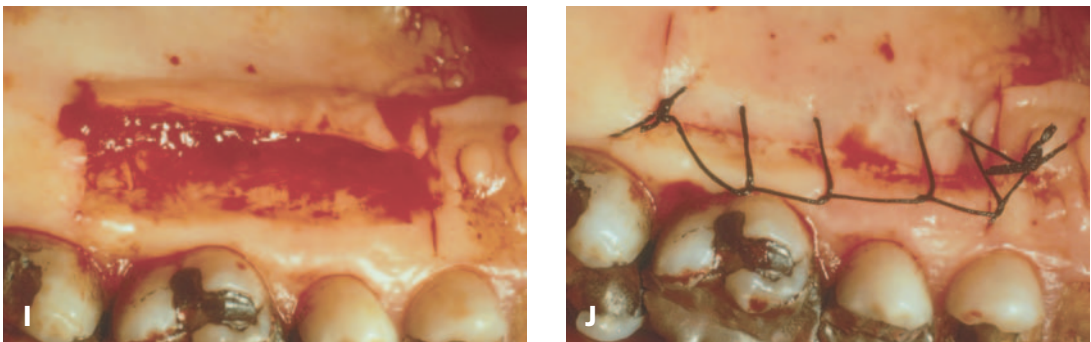
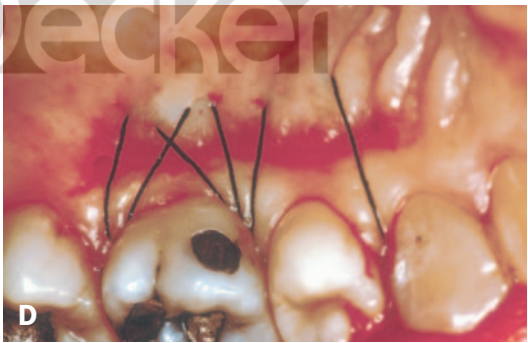


FIGURE 21-17. Part II. Modified or envelope technique. Subepithelial connective tissue donor site. *A*, Before. *B*, Horizontal incisions completed and graft undermined. Note that graft must be made longer to permit proper length of graft to be obtained. *C*, Graft removed. *D*, Final suturing.



Note: This suturing technique will inhibit graft mobility, prevent underlying clot formation, and promote initial graft viability.

4. The primary flap is now coronally positioned and sutured with 4-0 silk (P-3 needle) to cover as much of the graft as possible. The flap is positioned laterally with interrupted sutures and coronally with a suspensory sling suture (see Figure 21-15F).

It is important to note that 6 to 10 weeks after surgery, gingivoplasty is often required for establishing the final gingival contours and for reduction of tissue bulk.

Common Reasons for Failure

According to Langer and Langer (1992), common reasons for the failure of this procedure are as follows.

1. Recipient bed is too small to provide an adequate blood supply

2. Flap perforation(s)
3. Inadequate graft size
4. Inadequate coronal positioning of the flap
5. Connective tissue graft is too thick
6. Poor root preparation
7. Poor papillary bed preparation

The clinical procedure is depicted in Figures 21-18 to 21-32. Individual prosthetic and implant situations are depicted in Figure 21-26 through Figure 21-28 (prosthetic) and Figure 21-29 through Figure 21-31 (implants).

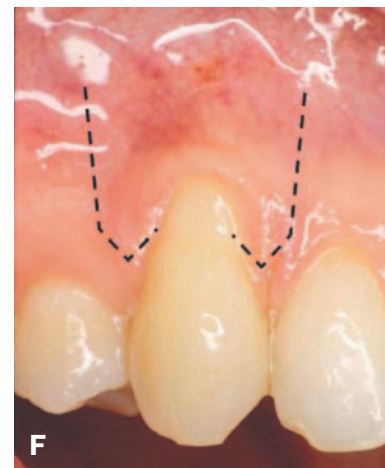
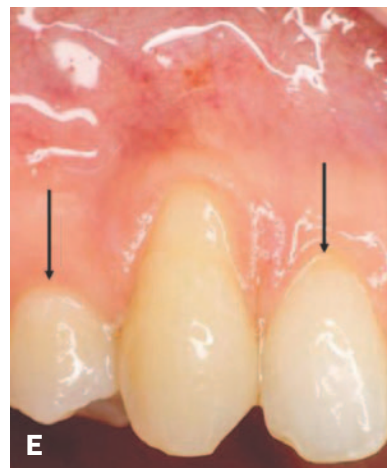
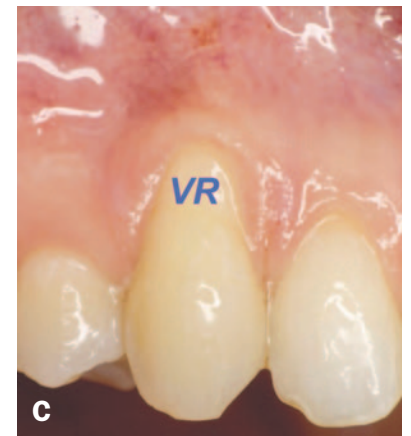
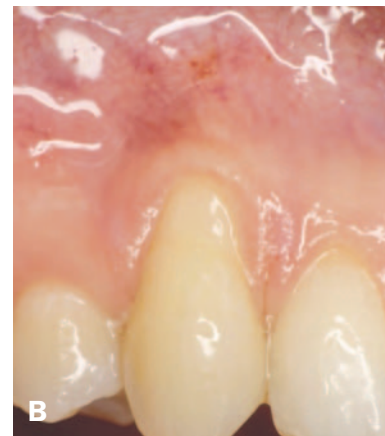


FIGURE 21-18. Basic procedure. A, Before with unsightly exposure of right cuspid. B, Before picture of the tooth to be treated. C, VR = visible recession. D, Arrows indicate coronal movement of tissue required to achieve root coverage and where papillary incision must begin. E, Arrows indicate areas that should be avoided on adjacent teeth. F, Outline of incision. G, Incisions complete.



FIGURE 21-18. Continued. H, Partial-thickness flap reflected exposing root. HR = hidden recession. I, DE = De-epithelialization of papilla; ARI = apical releasing incision to assure coronal movement of flap. J, De-epithelialization complete. K, SCTG stabilized laterally. L, SCTG stabilized circumferentially. M, SCTG stabilized apically (all sutures shown). N, Pedicle flap coronally positioned and sutured circumferentially. O, Lateral stabilizing sutures placed. Note that most apical suture is periosteal to prevent flap movement. P, All sutures placed and labeled (suspensory, 1, papillary; 4, facial; interrupted, 2, lateral; 3, lateral periosteal stabilizing suture). Q, Cyanoacrylate is placed. This is optional. R, Final clinical result at 6 months. Compare to Figure B. S, Final smile. Compare to Figure A.



FIGURE 21-19. SCTG using a coronally positioned and envelope flap. A, A', Before. B, B' Graft positioned and sutured with chromic sutures. Envelope prepared. C, C', Flap coronally positioned. D, D', Final results after a year with 100% root coverage.



FIGURE 21-20. A, Preoperative view of teeth 11 and '1 with significant recession. B, Crestal incision extended one tooth beyond areas of recession. C, Connective tissue graft positioned and stabilized with 5-0 chromic sling sutures. D, Flap undermined and coronally positioned and sutured with 5-0 vicryl sutures. Note that sutures are left in for two weeks. E, Cyanoacrylate is placed over the graft as post operative dressing and for stabilization. F, Final healing 6 months later. Compare to A.

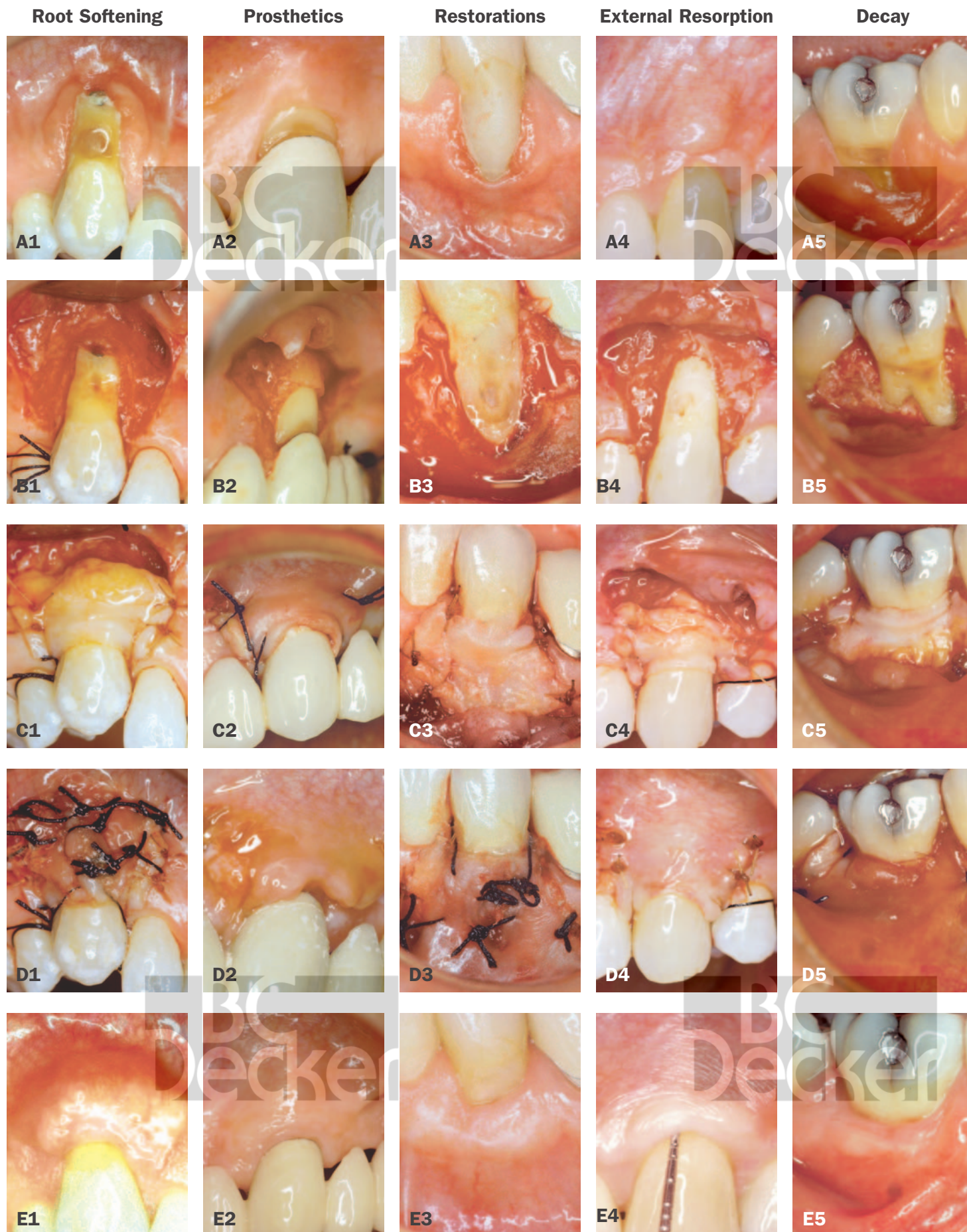
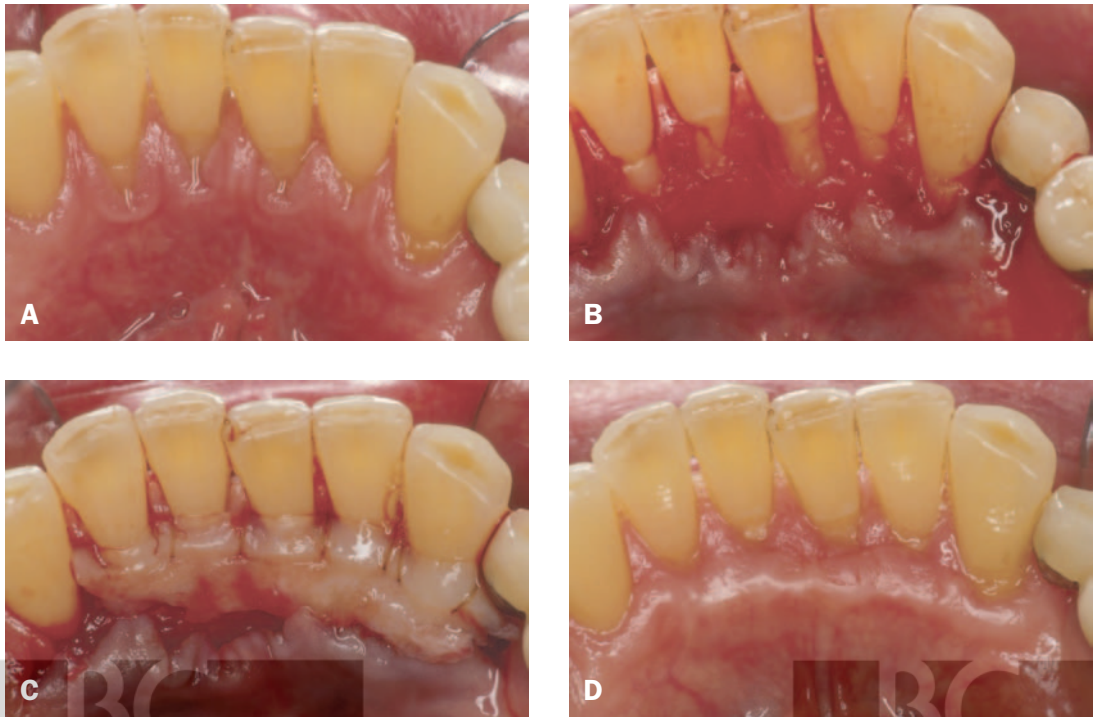
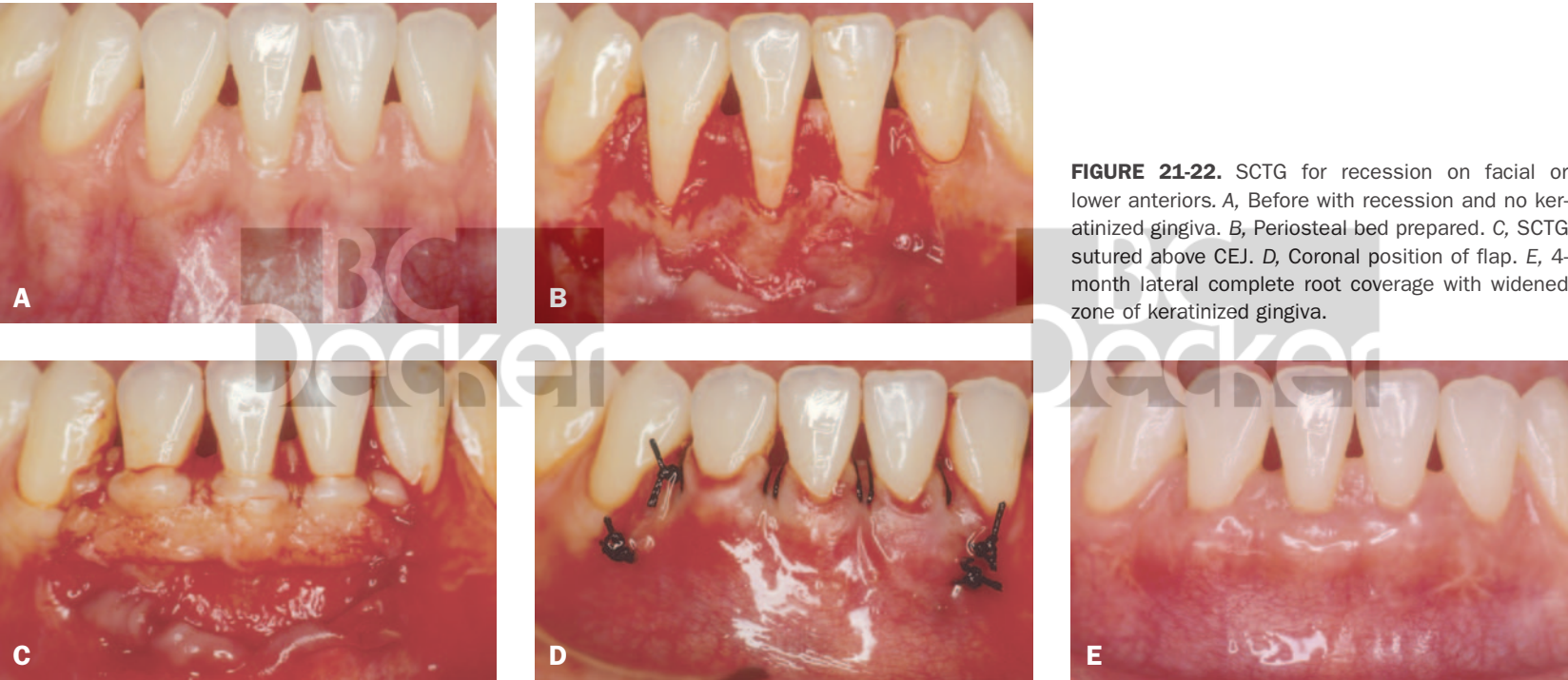


FIGURE 21-21. The subepithelial connective tissue graft use for treating multiple restorative problems on individual tooth. A1, B1, C1, D1, E1, Before root softening, prosthetics, restoration, external resorption, decay. A2, B2, C2, D2, E2, Roots scaled, debrided flattened. Fillings and decay removed. A3, B3, C3, D3, E3, SCTG placed and sutured. A4, B4, C4, D4, E4, Pedicle and double papilla flaps sutured to position. A5, B5, C5, D5, E5, Cases completed after 6 months, 5 years, 2 years, 12 months, and 10 months.



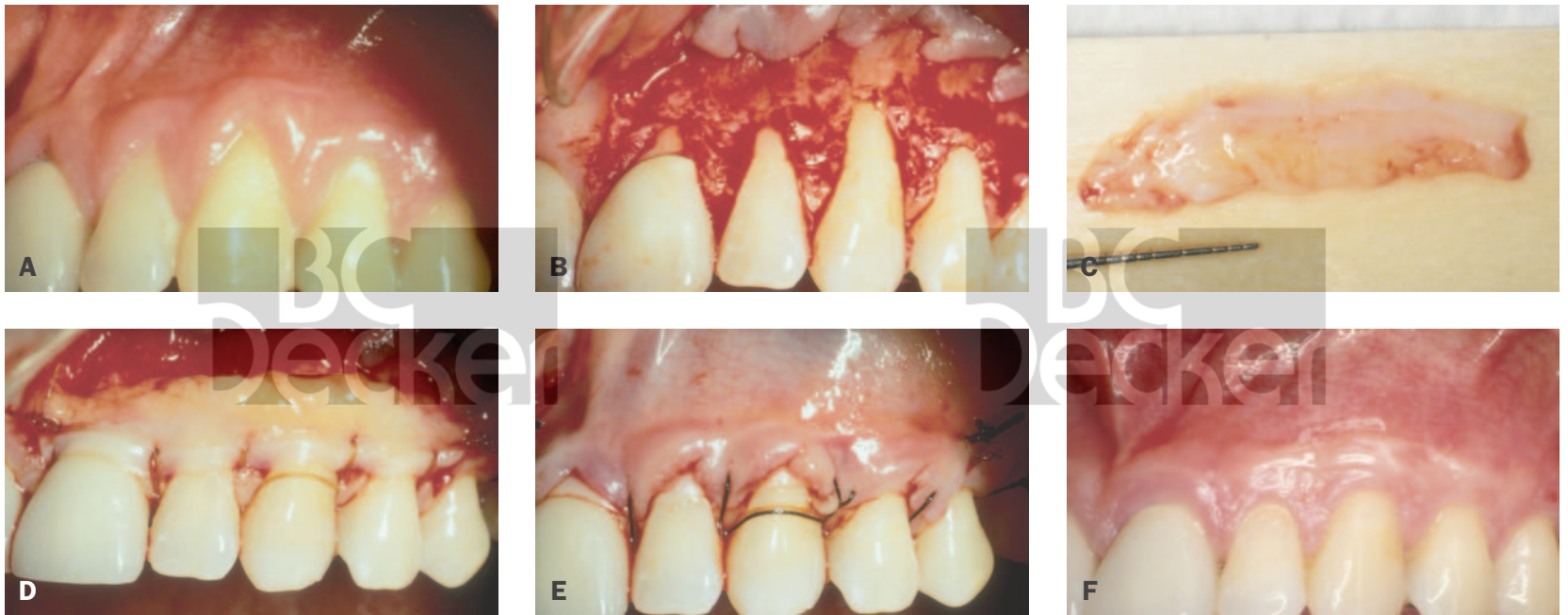


FIGURE 21-24. SCTG. A, Before treatment. Note multiple areas of recession. B, Partial-thickness flap reflected and recession exposed. C, Large connective tissue graft obtained. D, Connective tissue graft sutured with chromic gut sutures. E, Pedicle flap positioned and sutured coronally over graft. F, Six months later. Note excellent result.



FIGURE 21-25. SCTG for esthetic correction of anterior teeth. A, Before showing recession and minimal keratinization. B, Root planing and citric acid application completed. C, Initial incisions outlined. D, Partial thickness flap reflected. E, Long single SCTG removed. F, SCTG placed on teeth #7, 8, 9. G, Flap coronally positioned. H, 3 months later. Excellent clinical result. Courtesy of George Goumenos, Athens, Greece.

Subpedicle Connective Tissue Graft

Nelson (1987) modified Langer and Langer’s (1985) original technique by using a pedicle flap to cover the connective tissue graft. He called this a subpedicle bilaminar graft. He was able to achieve an average of 88% root coverage in a group of advanced cases with recession of 7 to 0 mm. Harris (1992) achieved 97.4% root coverage with the combination of a double-pedicle flap over a connective tissue graft. The subpedicle connective tissue graft may be either a single- or double-papillae flap.

Advantages

- 1. Predictable root coverage
- 2. Ability to increase the width of keratinized gingiva

Disadvantage

The main disadvantage is the difficulty in handling, positioning, and suturing small pedicle flaps.

Procedure

In Figures 21-33 (single papilla) and 21-34 (double papillae), the procedures are depicted.

- 1. The root surface is called and root planed to reduce and remove prominent cervical convexities. Finishing burs and biochemical root modifiers are optional.
- 2. A no. 15 scalpel is used to outline the surgical site, and a partial-thickness flap is chased by sharp dissection (see Figures 21-33B and 21-34B). As always, the sharp dissection is

begun at the mucogingival junction and carried coronally.

- 3. The flaps are reflected (see Figures 21-33C and 21-34C), and the connective tissue graft is obtained and sutured as previously described (see Figures 21-33D and 21-34D).
- 4. The pedicles are either singularly, as in a rotated pedicle flap (see Figure 21-34E), or dually, as in a double-papillae pedicle flap, sutured in place with 4-0 or 5-0 silk using a P-3 needle (see Figures 21-33F and 21-34F).

The clinical procedure for the single-papilla flap is depicted in Figures 21-37 to 21-39. The clinical procedure for the double-papillae flap is depicted in Figures 21-40 to 21-41.

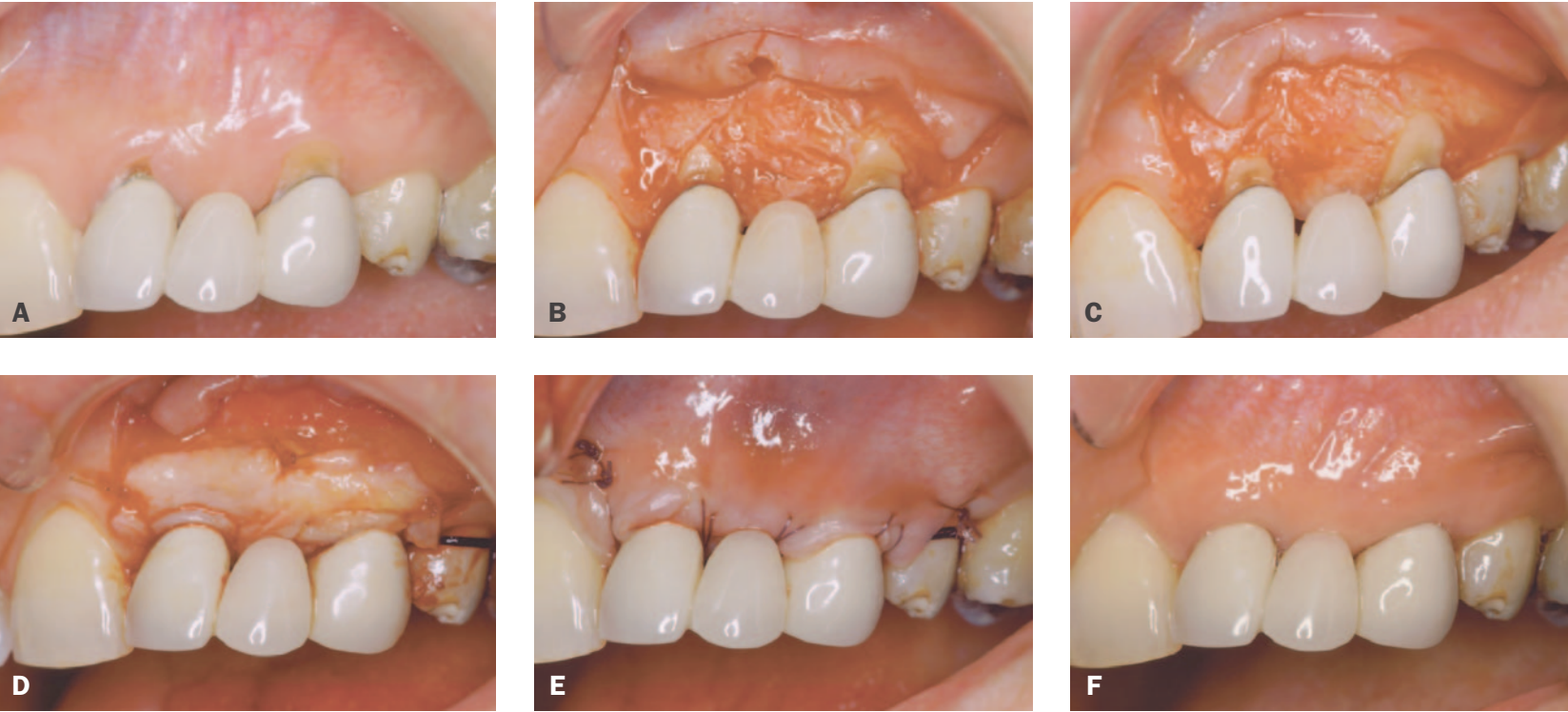


FIGURE 21-26. Subepithelial connective tissue graft for coverage of unsightly crown margins. A, Before. B, Partial thickness flap reflection exposing root abrasion. C, Root smoothed. D, Connective tissue graft sutured to position. E, Flap is coronally positioned. F, Final 10 months later showing 100% coverage with stable esthetic result.



FIGURE 21-27. SCTG prior to prosthetics. *A*, Before. Smile with unsightly long teeth with spaces. *B*, Before, lateral view. *C*, SCTG sutured. *D*, Coronally positioned flap with complete graft coverage. *E*, *F*, Lateral and smile views of final prosthetic case treated with laminates. (Prosthetics by Dr. Michael Katz, Westport, MA.)



FIGURE 21-28. SCTG for a combination of decay and unsightly crown margin. *A*, Before. *B*, Cervical decay exposed. *C*, Root surfaces smoothed and decay removed. *D*, Graft procedure. *E*, Graft sutured to position. *F*, Flaps coronally positioned and sutured. *G*, Final result 8 months later. *H*, 5 years later.

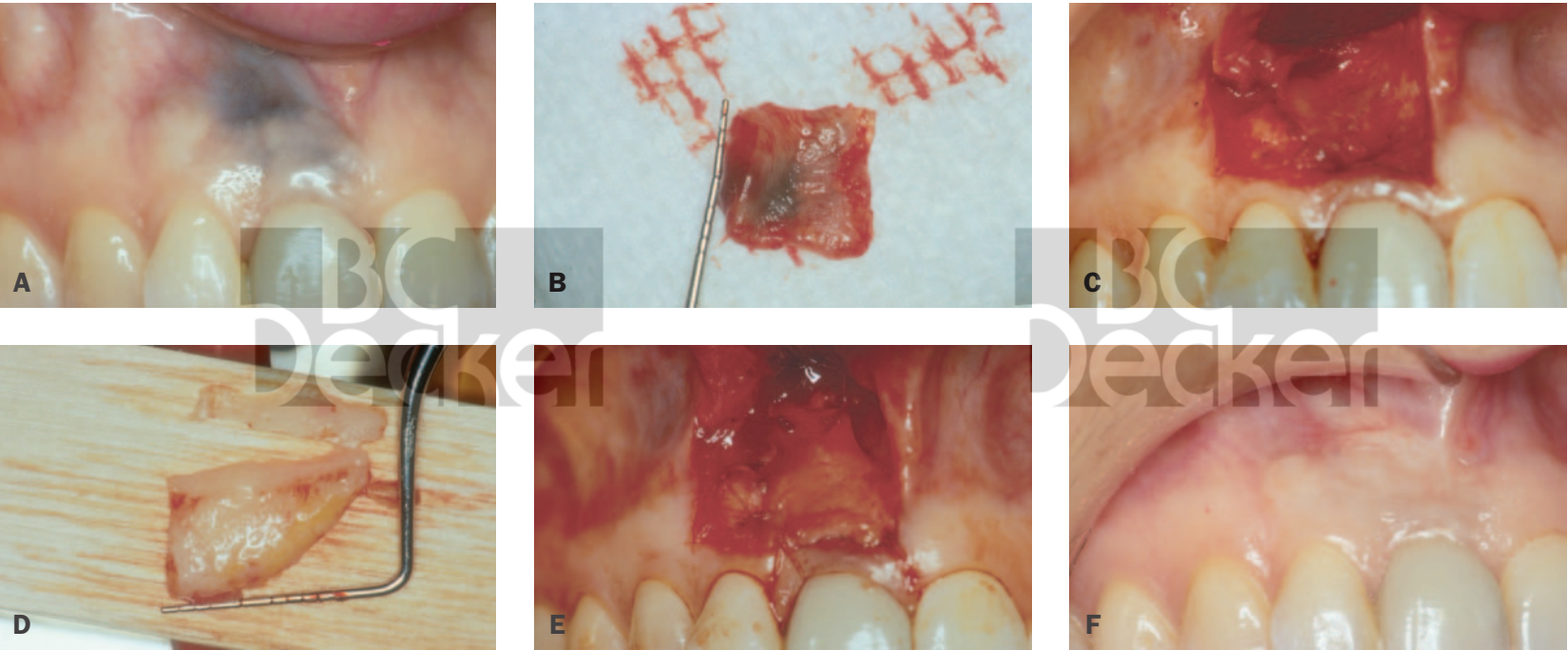


FIGURE 21-29. Use of C.T. graft for treatment of amalgam tattoo. A, Before, unsightly amalgam tattoo. B, Tattoo removed. C, Periosteal bed prepared. D, C.T. Graft harvested. E, Graft sutured to position. F, Final result with complete removal of tattoo. (Contributed by Dr. Scott Kissel, New York, NY and James Hanratty, Swampscott, MA.)



FIGURE 21-30. SCTG for esthetic ridge form at time of implant exposure. A, Before, tooth #1 is to be extracted. B, Tooth extracted and implant placed. C, DFDBA and nonresorbable membrane placed. D, Ridge at time of exposure. E, Implant exposed. F, SCTG sutured to position. G, Final ridge contour. Compare to Figure D. H, Final esthetic result.

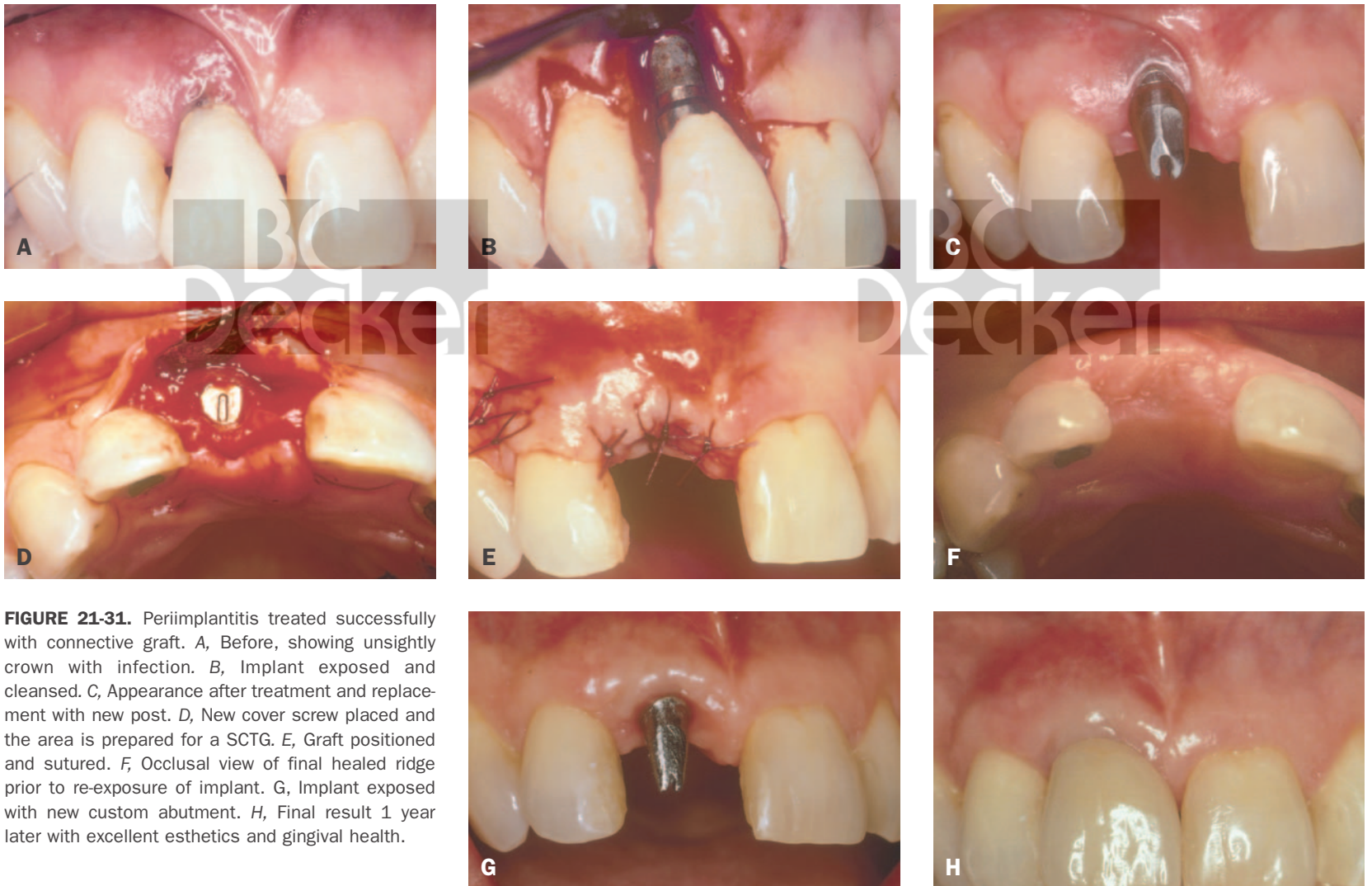


FIGURE 21-31. Periimplantitis treated successfully with connective graft. *A*, Before, showing unsightly crown with infection. *B*, Implant exposed and cleansed. *C*, Appearance after treatment and replacement with new post. *D*, New cover screw placed and the area is prepared for a SCTG. *E*, Graft positioned and sutured. *F*, Occlusal view of final healed ridge prior to re-exposure of implant. *G*, Implant exposed with new custom abutment. *H*, Final result 1 year later with excellent esthetics and gingival health.

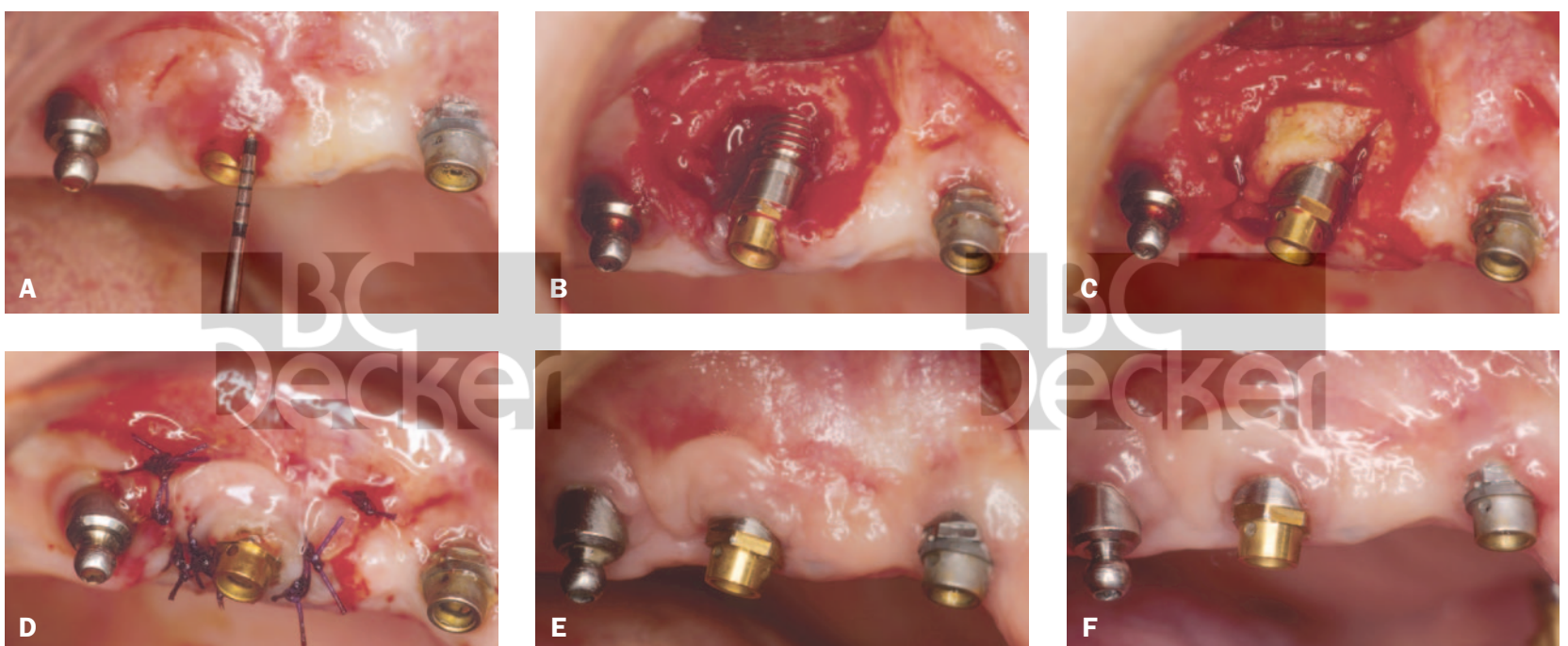


FIGURE 21-32. SCTG for treatment of periimplantitis. *A*, Before with probe showing 10 mm probing. *B*, Implant exposed and cleansed. *C*, SCTG placed. *D*, Flap repositioned and sutured. *E*, *F*, 4 months and 1 year showing excellent results with no probing.

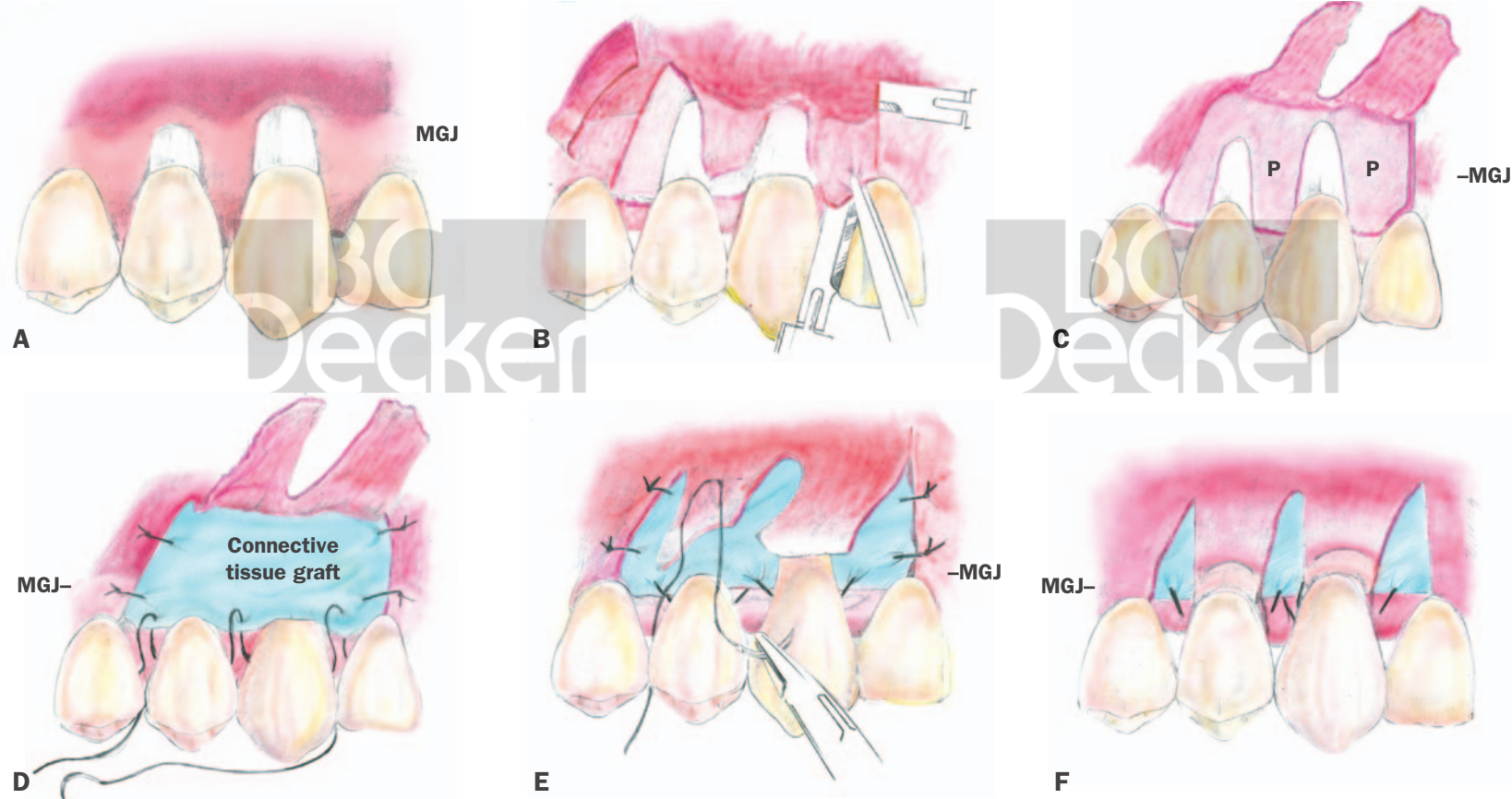


FIGURE 21-33. Subepithelial connective tissue graft: modified technique. *A*, Before surgery, with incisions outlined. *B*, Sharp dissection of a partial-thickness pedicle flap. *C*, Periosteal bed prepared. *D*, Connective tissue graft sutured. *E*, Pedicle flaps being sutured over the radicular surface. *F*, Final suturing with pedicles covering the facial aspect of the graft.

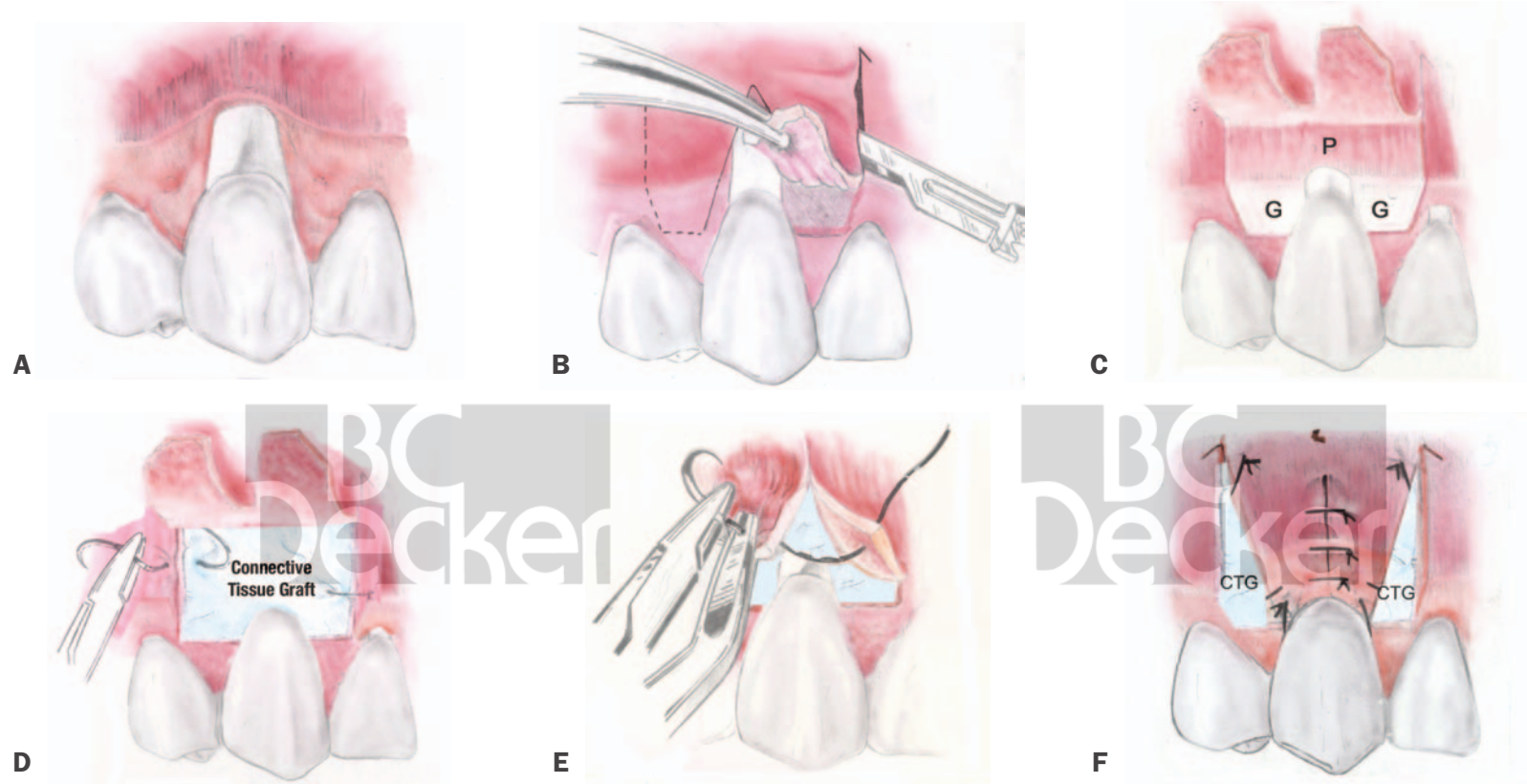


FIGURE 21-34. Subepithelial connective tissue graft. Modified technique. *A*, Double papilla incisions outlined. *B*, Partial-thickness flap completed by sharp dissection. *C*, Periosteal bed prepared. *D*, Connective tissue graft sutured. *E*, Double papilla flaps being sutured over the graft. *F*, Suturing completed. Radicular surface of graft covered by tissue.

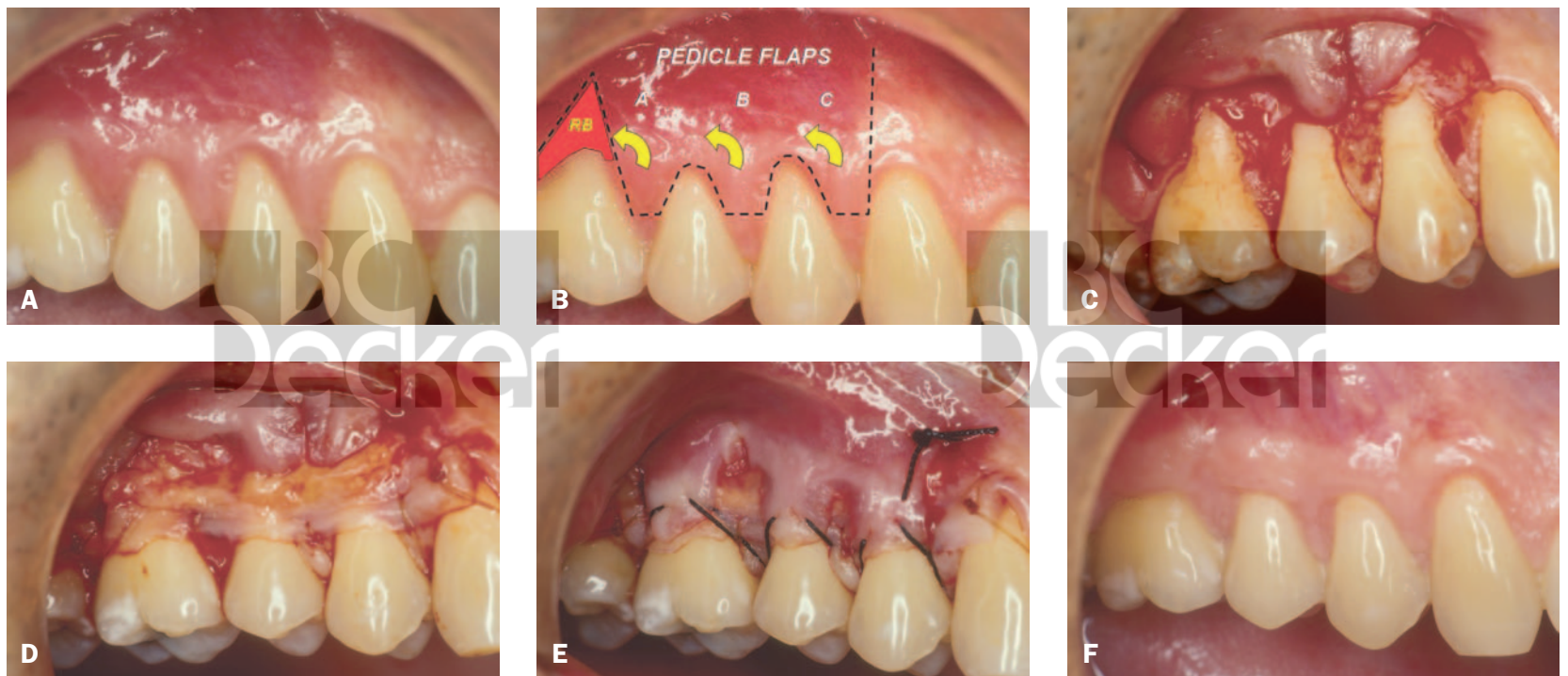


FIGURE 21-35. SCTG using multiple pedicle flaps. Double and lateral papillary flaps. A, Before recession with no keratinized gingiva. B, Incisors outlined. C, Biochemical root debridement. D, Partial thickness flaps reflected. E, Flaps sutured to position over grafts. F, Final, 8 months later with 100% root coverage and wide zone of keratinized gingiva. Compare to Figure A..

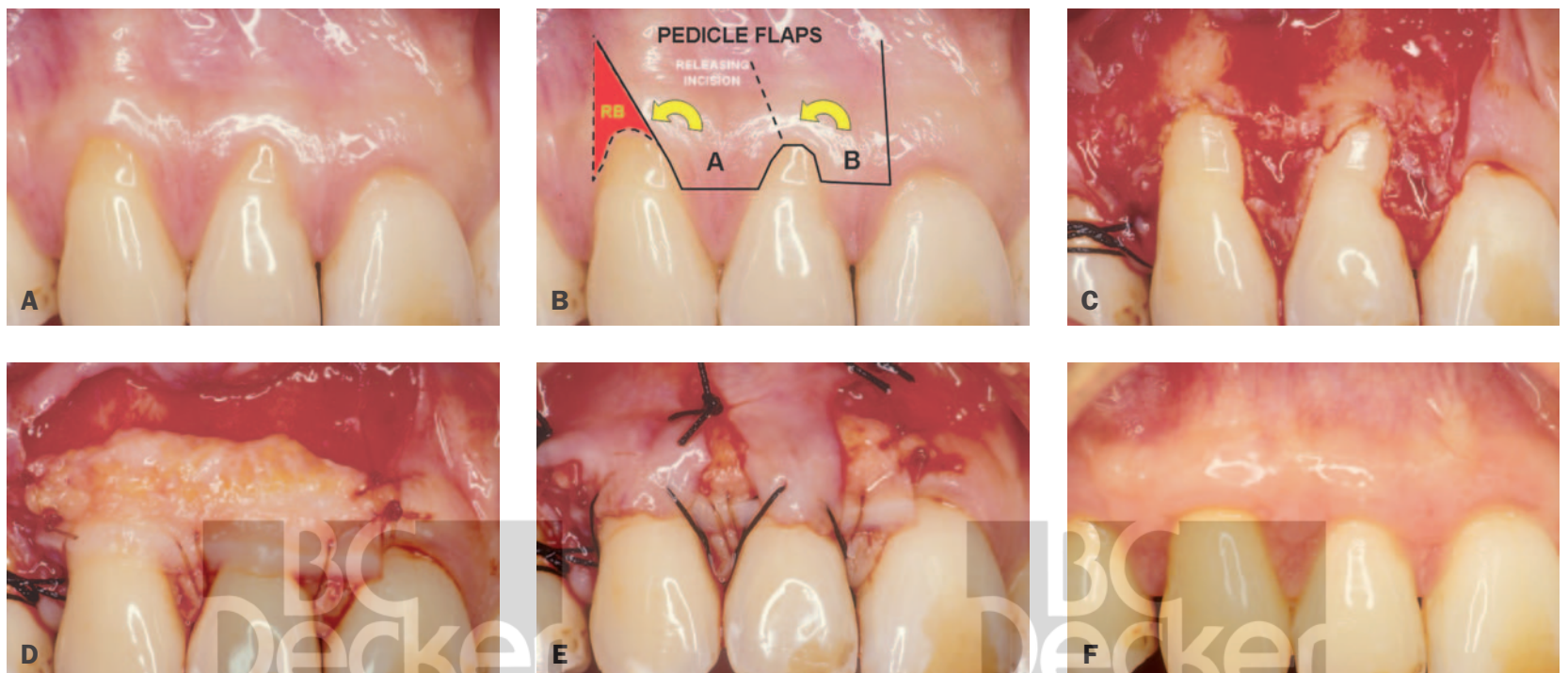


FIGURE 21-36. SCTG utilizing rotating pedicle flaps. A, Before. B, Outline of incisions. C, Partial thickness flap. D, Graft sutured with 5-0 chromic sutures. E, Pedicles sutured to position. F, 7 months later. Complete root coverage with wide zone of keratinized gingiva.

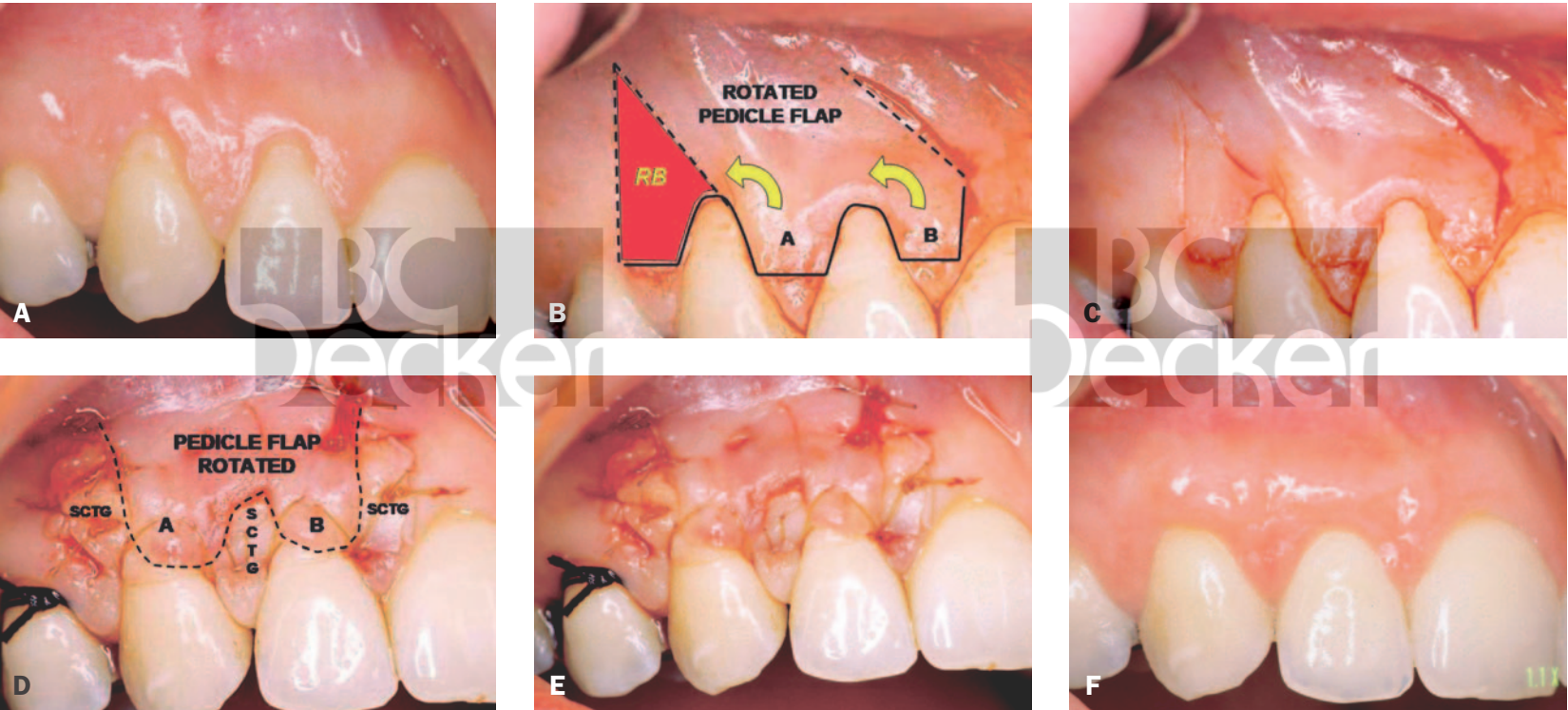


FIGURE 21-37. A, Before. B, Outline of incision. C, Incisions completed. Note the angulation of incisions. D, Outline of pedicle flap position. E, Pedicles sutured with 4-0 chromic sutures. F, Final case 12 months after with 100% coverage and wide zone of keratinized gingiva.

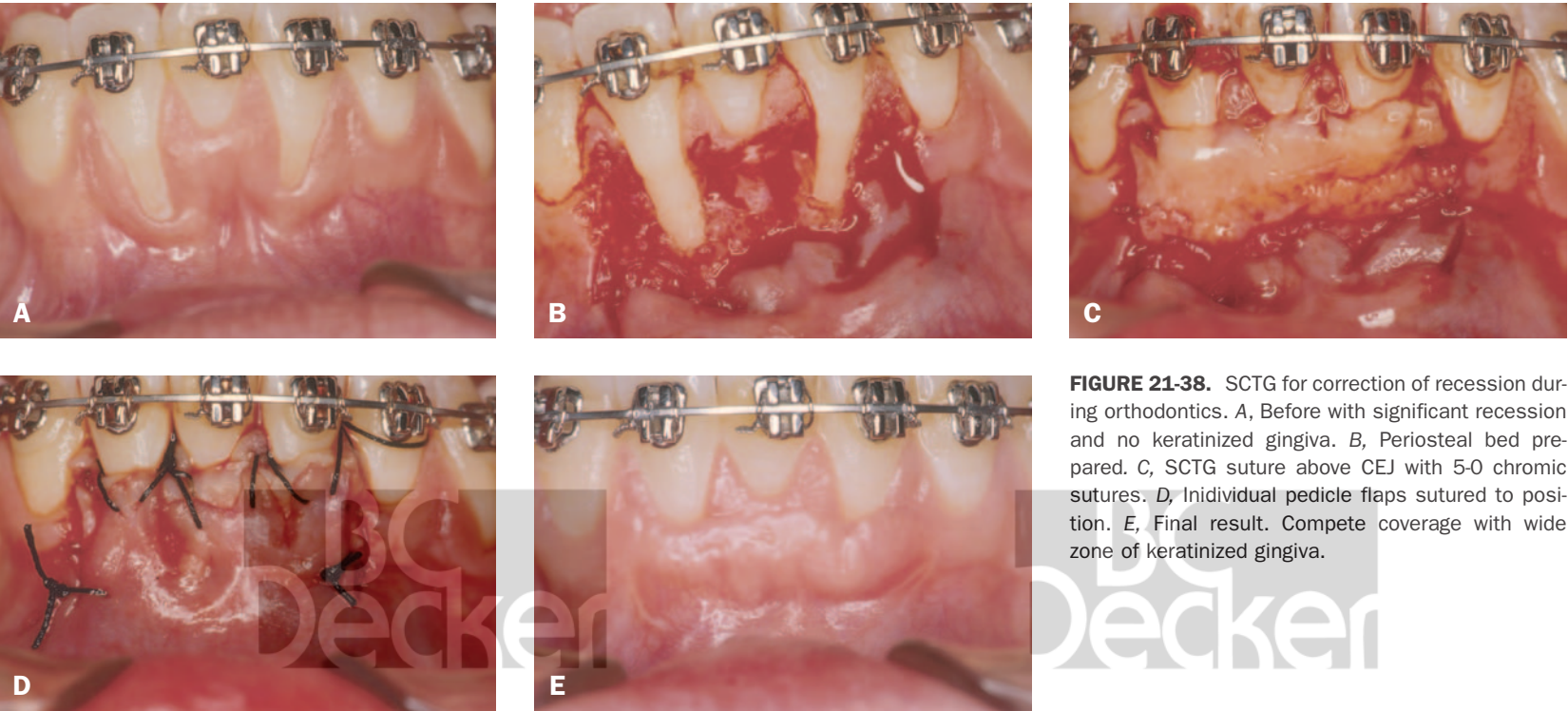


FIGURE 21-38. SCTG for correction of recession during orthodontics. A, Before with significant recession and no keratinized gingiva. B, Periosteal bed prepared. C, SCTG suture above CEJ with 5-0 chromic sutures. D, Individual pedicle flaps sutured to position. E, Final result. Complete coverage with wide zone of keratinized gingiva.

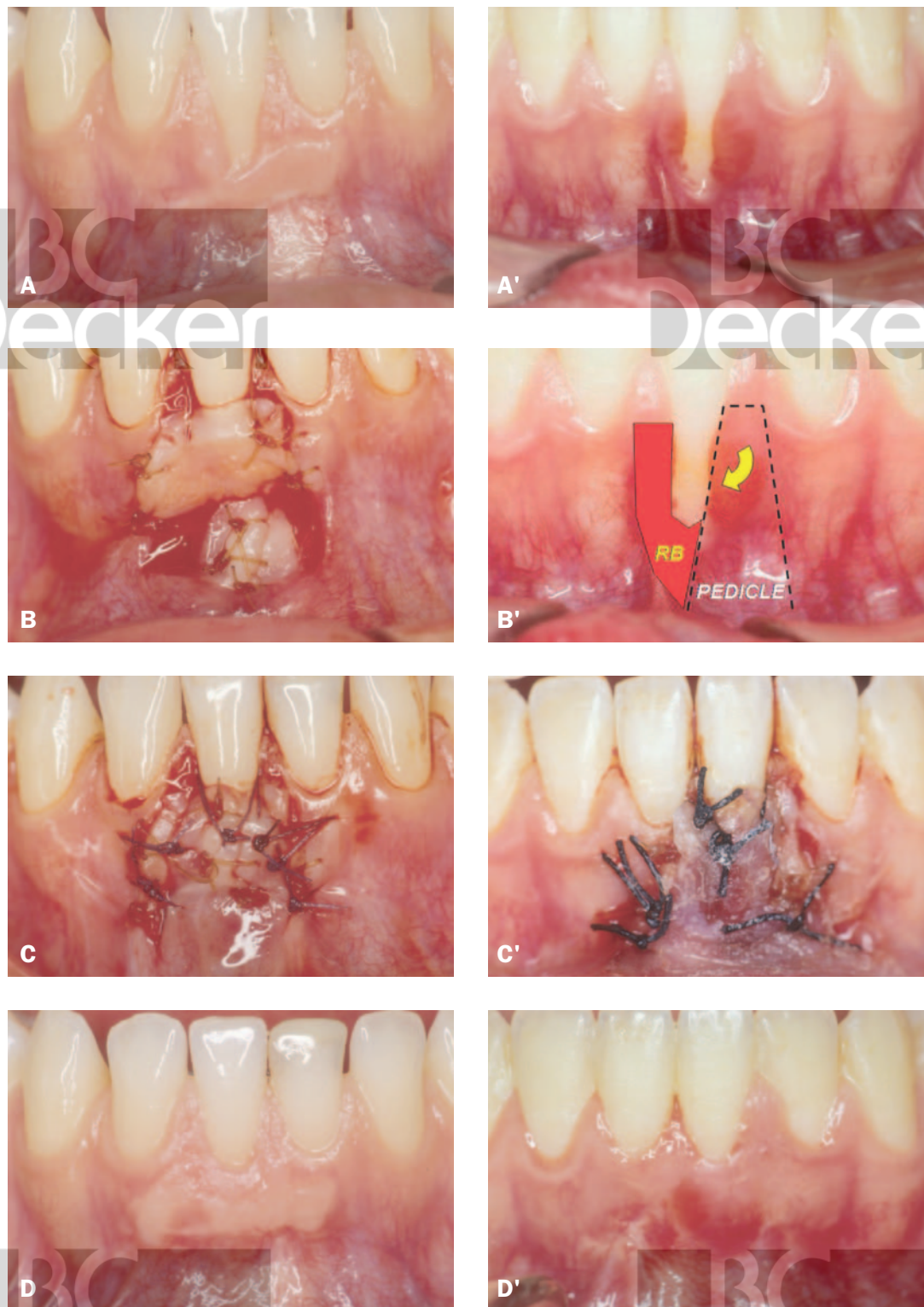
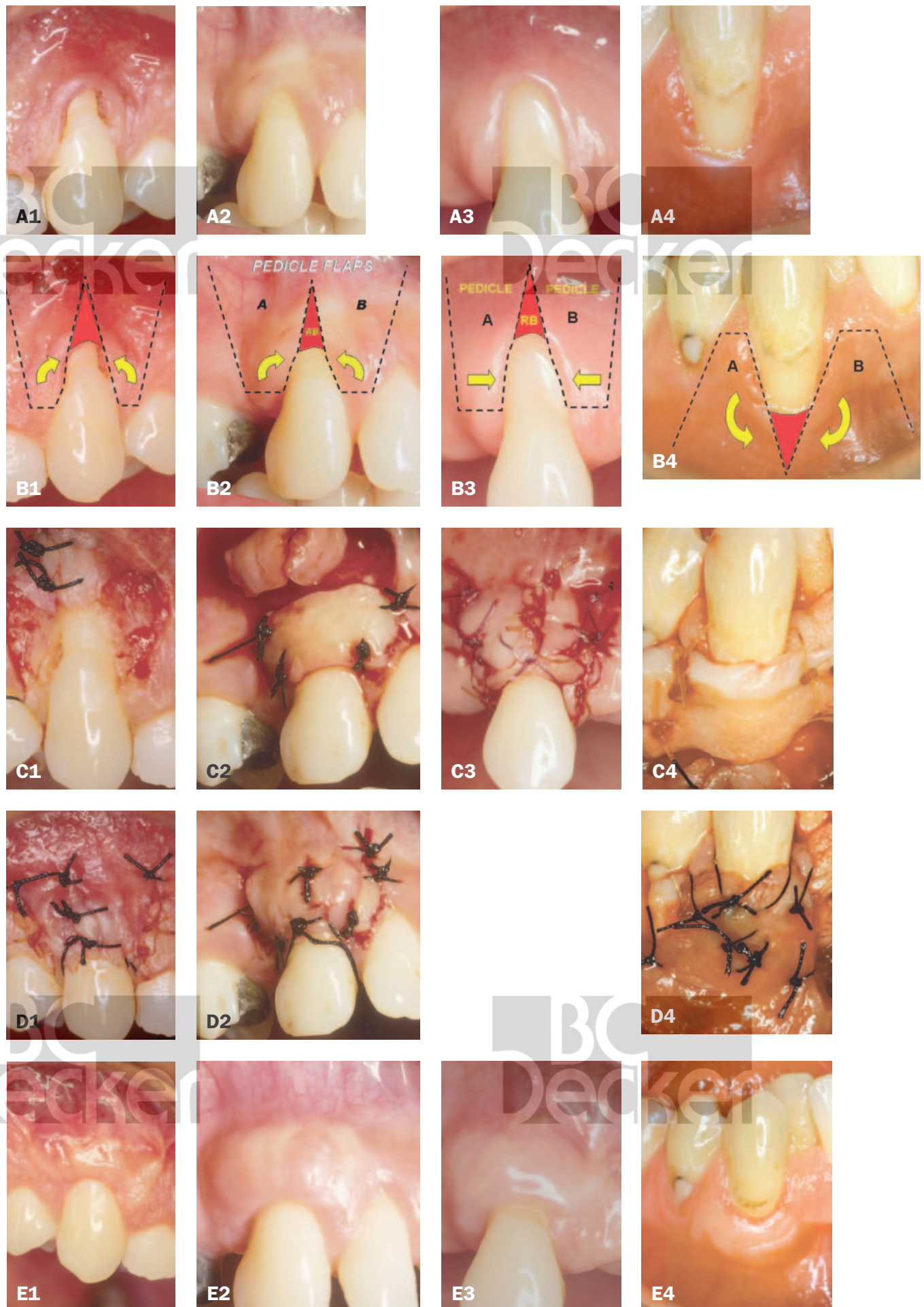


FIGURE 21-39. SCTG on lower anterior teeth for treatment of recession. *A*, Before after unsuccessful prior free gingival graft treatment. *A'*, Before after orthodontic treatment. *B*, Connective tissue graft and double papilla flap sutured. *B'* Outline of proposed pedicle flap. *C*, Double papilla flap sutured. *C'* Pedicle sutured and stabilized with cyanoacrylate. *D*, *D'* Final results 8 months later showing 100% root coverage and wide zones of keratinized gingiva.



FIGURE 21-40. Subepithelial connective tissue graft using multiple pedicle flaps. Double and lateral papillary flaps. A, Before, recession with no keratinized gingiva. B, Incisors outlined: A = pedicle flap; B and C = double papilla flap. C, Biochemical root debridement. D, Partial thickness flaps reflected. E, Flaps sutured to position over connective tissue graft. F, Final case 8 months later with 100% root coverage and wide zone of keratinized gingiva. Compare to A.

FIGURE 21-41. SCTG using double papilla flaps. A1, B1, C1, D1, E1, Before showing recession and minimal zones of keratinized gingiva. D shows incision outline. A2, B2, C2, D2, E2, Outline of incisions. Graft placement with chromic sutures. A3, B3, C3, D3, E3, Suturing with 4-0 to 6-0 silk sutures. A4, B4, C4, D4, E4, 8-12 months later. Note complete root coverage with thickened tissue and wide zones of keratinized gingiva.



Semilunar Flap

The semilunar flap, a modification of the coronally positioned flap, was originated by Tarnow (1986). It is designed primarily for attaining esthetic root coverage where 2 to 3 mm of root coverage is required.

Indication

Areas in which gingival recession is only 2 to 3 mm

Advantages

- 1. No vestibular shortening as occurs with the coronally positioned flap
- 2. No esthetic compromise or interproximal papillae
- 3. No need for sutures

Disadvantages

- 1. Inability to treat large areas of gingival recession

- 2. The need for an FGG if there is an underlying dehiscence or fenestration

Requirements

- 1. Lack of tissue inflammation
- 2. Minimal pocket depth labially

Procedure

- 1. The exposed root surface is root planed and biochemically modified (optional).
- 2. The incisions are outlined in Figure 21-42, A and B. This is a partial-thickness procedure.
- 3. A no. 15 scalpel blade is used to outline a semilunar incision that follows the curvature of the gingival margin (Figure 21-42C). The incision is not made down to bone.
- 4. The midfacial part of the incision should be high enough to ensure that after the flap is coronally positioned, the apical portion of the flap will still rest on bone (see Figure 21-41B).

Note: If there is not enough keratinized gingiva, the semilunar incision is made in the mucosal tissue (see Figure 21-42C).

- 5. The incision is extended into the papillae on each side, making sure that at least 2 mm of lateral tissue is left to ensure an adequate blood supply (Figure 21-42D).
- 6. A partial-thickness flap is raised from the initial sulcular incision to the semilunar incision (Figure 21-42E).
- 7. The midfacial tissue is positioned coronally to the CEJ. Pressure is applied for 5 minutes. The area is packed, and the patient is placed on a soft diet for 10 days and is told to brush carefully (see Figure 21-42E).

The clinical procedure is depicted in Figures 21-43 and 21-44.

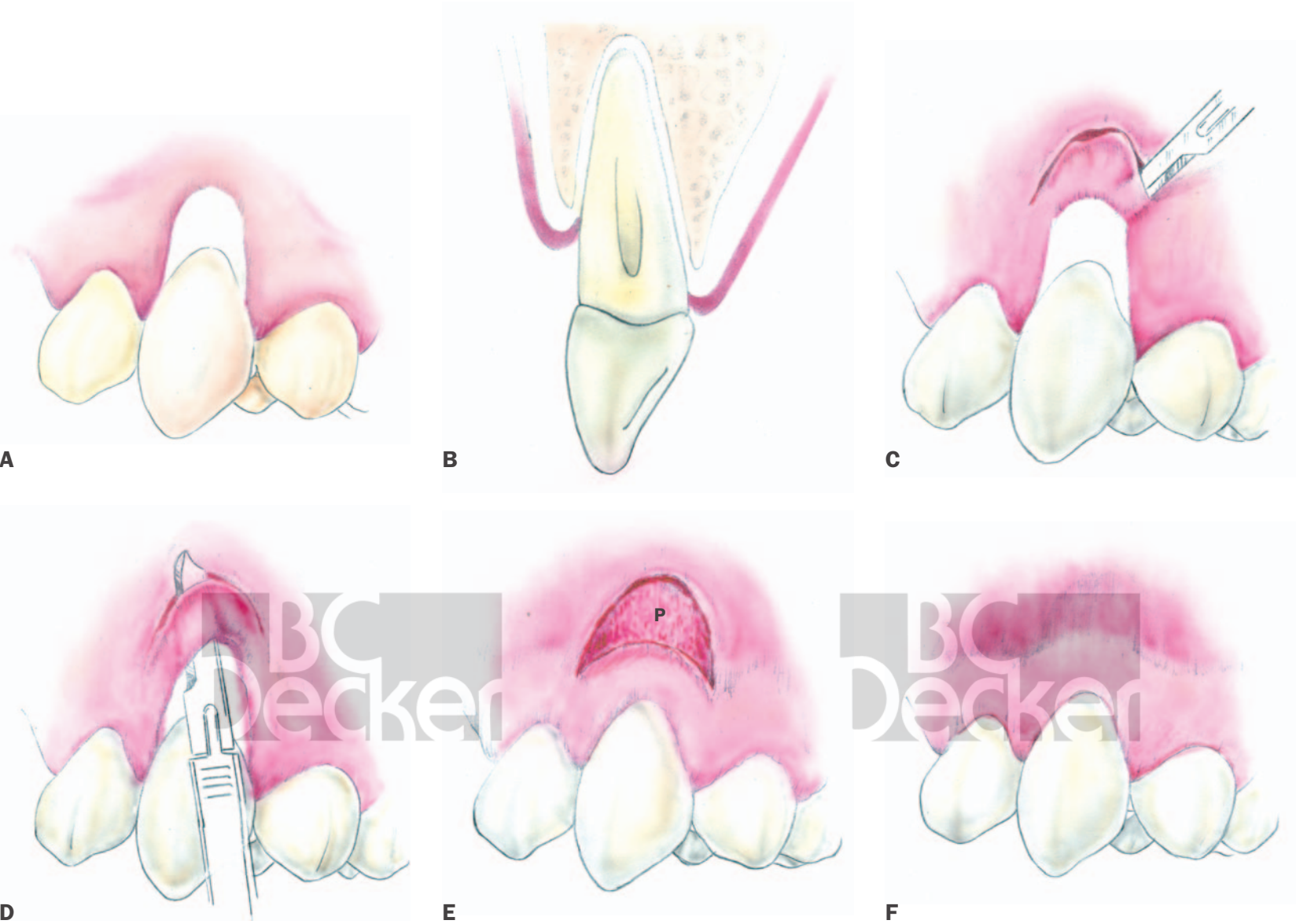
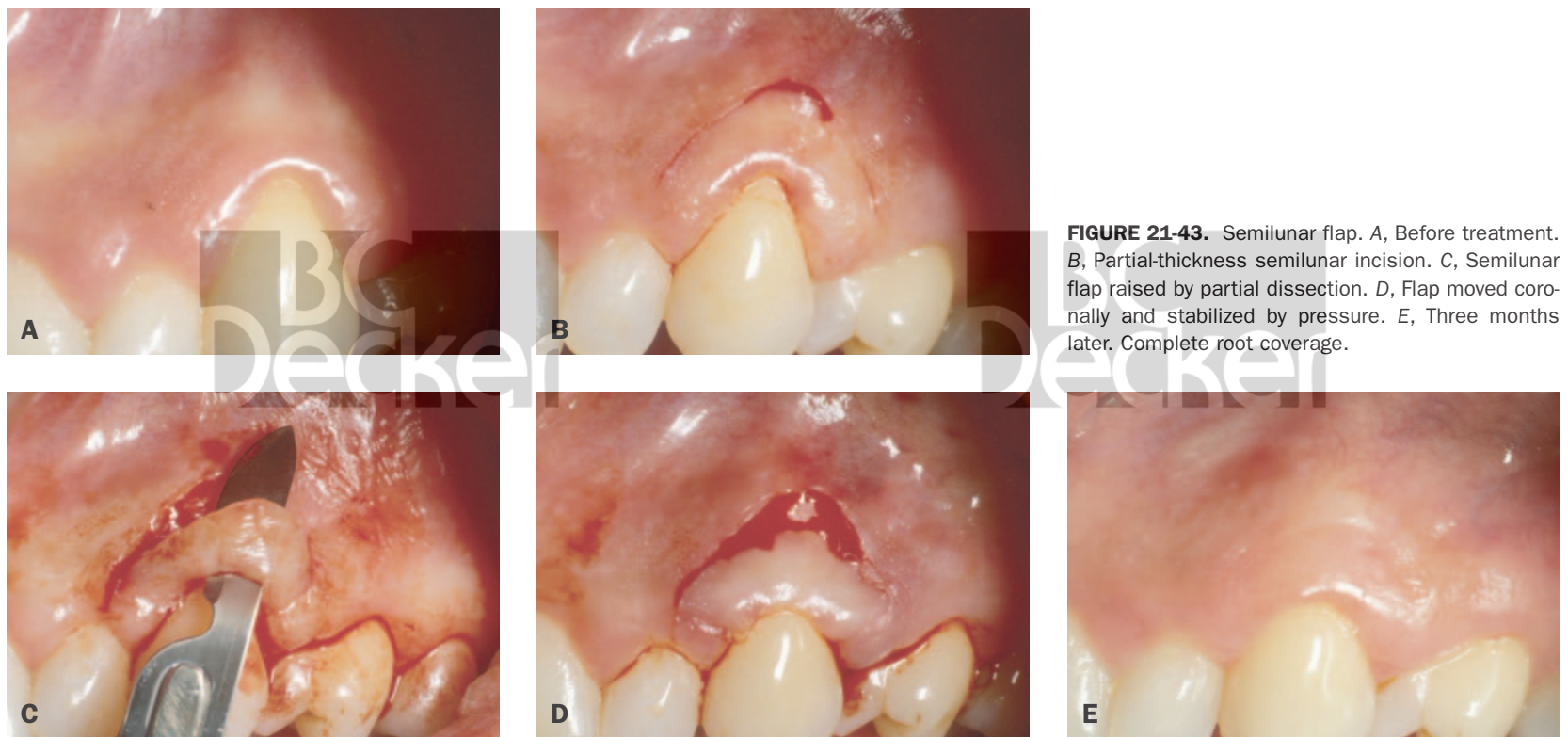


FIGURE 21-42. Semilunar flap. A, Before treatment. Incisions outlined buccally. B, Side view showing that the incision is extended far enough apically. C, A semilunar incision is made by sharp dissection but not down to bone. D, The partial-thickness flap is via the sulcus. E, The semilunar flap is now moved coronally. F, Completed case.



Transpositional Flap

This technique, as outlined by Bahat and colleagues (1990), appears to be a modification of the laterally positioned papillary flap as originally described by Pennel (1965), Hattler (1967), and Garber and Rosenberg (1984).

Advantages

1. Simple
2. Predictable for narrow areas of root exposure.
3. Versatile
4. Avoids recession at donor site

Disadvantages

1. Cannot treat multiple teeth
2. Limited primarily to narrow areas of recession
3. Requires a wide papilla

Procedure

1. A no. 15 scalpel blade is used to outline two partial-thickness flaps (primary or donor, secondary or recipient). The primary, or donor, flap is partial thickness to the mucogingival line and full thickness apical to it (Figure 21-45A and 45B).
2. The outlined incisions of the primary flap follow obliquely along the exposed root surface, resulting in a pedicle flap with a wider base. These incisions are extended apically enough to ensure freedom of movement and permit a thick base (1.5–2 mm) with adequate vascularity (see Figure 21-45B).
3. The recipient periosteal bed is prepared by raising and disregarding the secondary flap using sharp dissection with a no. 15 blade (Figure 21-45C).
4. Sharp dissection beginning below the mucogingival junction and moving the blade in an apicocoronal direction is used to raise the partial-thickness primary flap (see Figure 21-45C).
5. The pedicle is freed and released apically to ensure freedom of movement (Figure 21-45D).
6. The flap edge is sutured to the adjacent interproximal papilla at least 2 mm anterior to the defect. This is to avoid possible cleft formation (Figure 21-45E).
7. The flap is now secured about the neck of the tooth by suturing the midflap portion to the remaining exposed papilla. Lateral sutures are for stabilization and approximation of the flap to the adjacent tissues (Figure 21-45F).
8. Pressure is applied for 10 minutes for initial clot stability.

The clinical procedure is depicted in Figure 21-46.

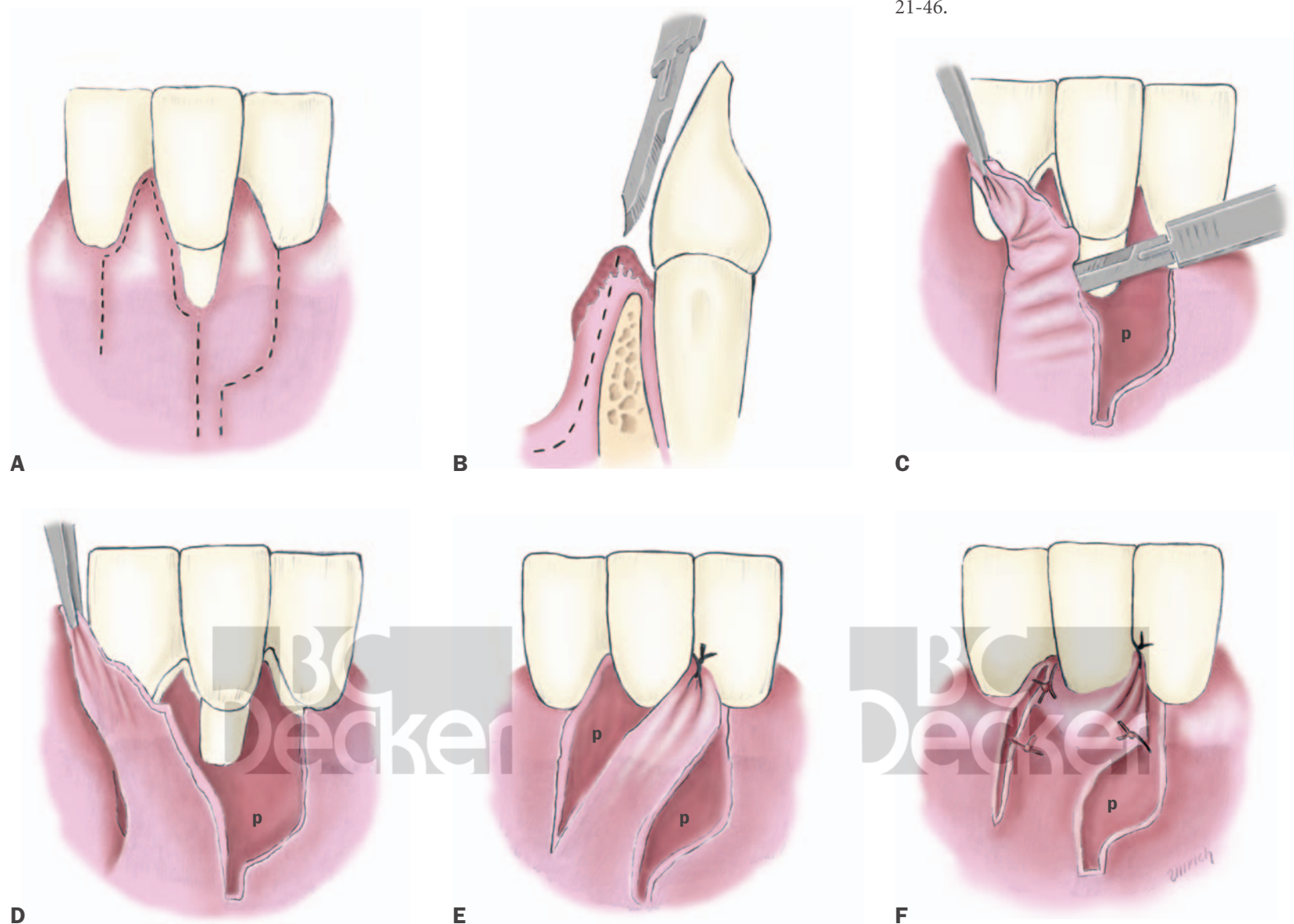


FIGURE 21-45. The transpositional papillary flap. *A*, Before surgery; incisions are outlined. *B*, Side view showing a partial-thickness flap design. *C*, The recipient site has been prepared, and the donor pedicle is prepared by sharp dissection. *D*, The pedicle flap is released apically. *E*, The initial suture positions the papilla at the cemento-enamel junction to the underlying recipient bed. *F*, The papilla is now anchored mesially, distally, and apically.

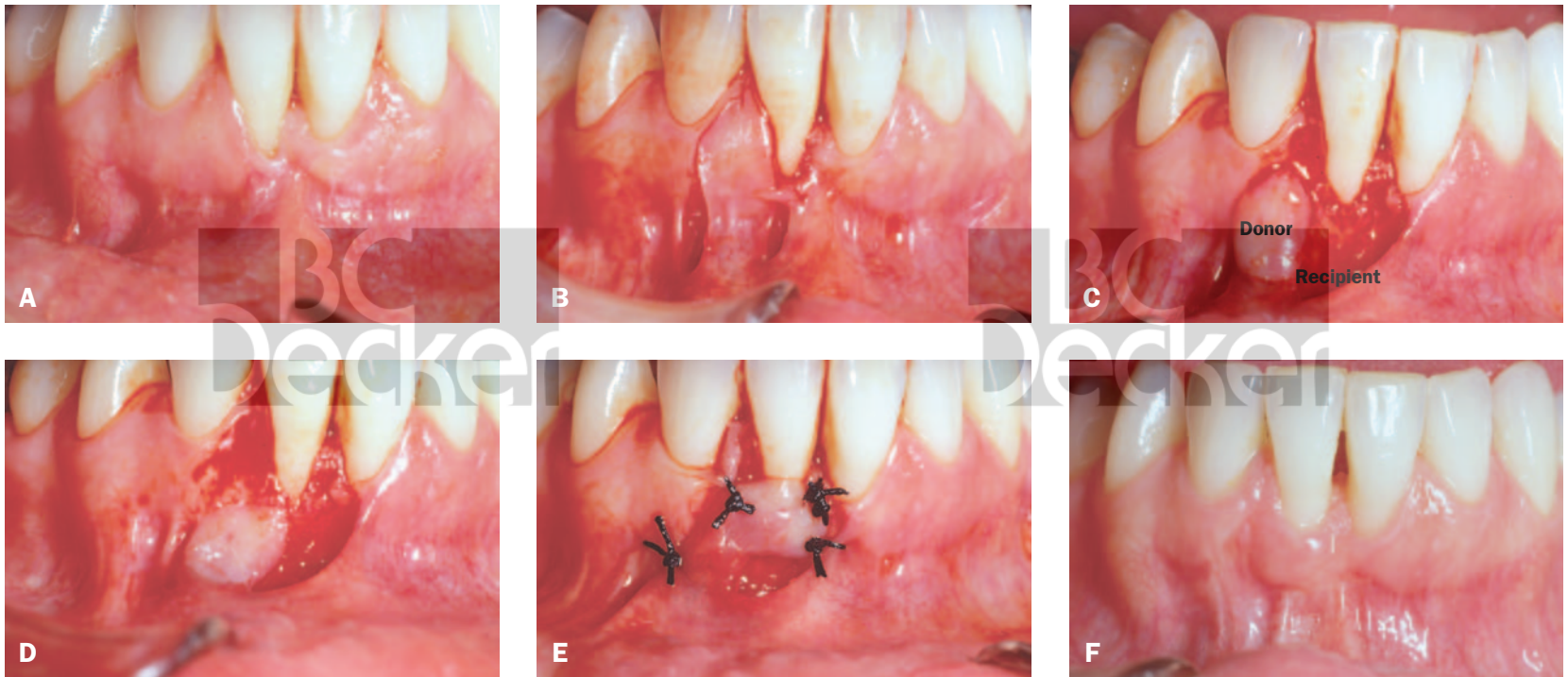


FIGURE 21-46. Transpositional rotated pedicle flap. A, Before treatment. B, Partial-thickness pedicle flap outlined. C, Partial-thickness recipient bed prepared. D, Pedicle flap released and removed apically. E, Pedicle rotated and sutured over the denuded root surface. F, Five months later.

Connective Tissue Pedicle Graft

Carvalho and colleagues (1982) published a report on a modification in which the periosteum from the periosteal bed is used as a single- or double-pedicle flap for enhancing root coverage. The theory is that the pedicle increases the chance of graft survival over the denuded root by increasing the plasmatic circulation in the avascular area.

Procedure

The periosteal bed at the recipient site is prepared by sharp dissection in the usual way; epithelial denudation is completed (Figure 21-47A).

The connective tissue pedicle flap is obtained by making an oblique incision on one or both sides of the tooth (Figure 21-47B). The size of the pedicle varies with the size of the denuded root surface.

The pedicle(s) is raised by blunt dissection and held with Corn suture pliers as a 5-0 silk suture is passed through it (Figure 21-47C).

In Figure 21-47, D and E show the suturing used when one or two pedicles are employed. Figure 21-47F represents graft placement and suturing.

This procedure is depicted clinically in Figure 21-48.

Guided Tissue Regeneration and Gingival Recession

Cortellilni and colleagues (1991), Tinti and colleagues (1992), McGuire (1992), and Prato and colleagues (1992) recently advocated the use of guided tissue regeneration for correction of gingival recession. Although successful results are achievable, they do not surpass those of the FGG or the SCTG. The procedure is more complex in that a second surgical procedure is required. For that reason, it is not advocated for routine use unless bone regeneration is desired.

Regenerative Tissue Matrix (AlloDerm® [LifeCell Inc. Palo Alto, California])

Plastic periodontal therapy was begun by Miller (1985) with the thick FGG. Langer and Langer's (1982) introduction of the SCTG made periodontal plastic surgery both highly predictable and very esthetic while decreasing morbidity, pain, and postoperative problems. The SCTG has become the foundation on which modern periodontal plastic surgery is built.

Still, grafting requires a second surgical donor site, which is the palatal area. In most instances, this is not a problem, but in cases that require or have the following, it often is:

1. Multiple areas of recession
2. Limited donor tissue
 - a. Small palate
 - b. Thin tissue
 - c. Flat or broad palate

As a result, the patient is subject to

1. Multiple surgical procedures
2. Increased morbidity
3. Increased pain
4. Delays in treatment owing to healing
5. Increased chair time
6. Increased patient anxiety
7. Decreased patient acceptance

The drive to find suitable alternatives has led to the use of a number of alternative materials:

1. Fascia laria (Callan, 1990)
2. Freeze-dried skin (Yukna and colleagues, 1977)
3. Guided tissue regeneration
 - a. Guidor® (Guidor AB, Huddinge, Sweden) (Harris, 1998)
 - b. Gore-Tex (Pini Prato and colleagues, 1993; Jensen and colleagues, 1998)
 - c. Biomend (Wang and colleagues, 1999)
 - d. Bioguide (Burns and colleagues, 2000)
 - e. Epiguide
 - f. Emdogain
 - g. Vicryl (DeSanctis and Zucchelli, 1996)

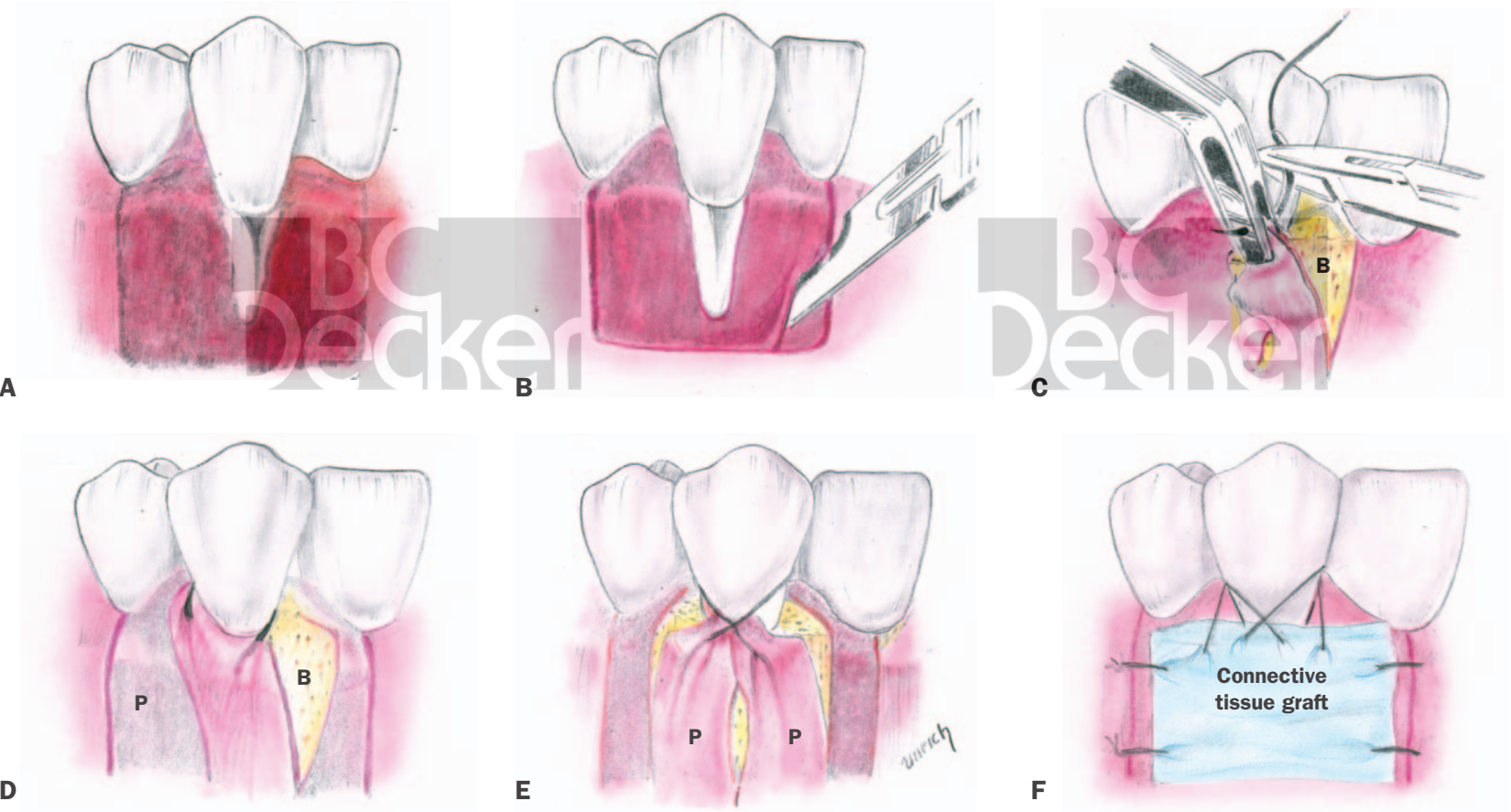


FIGURE 21-47. Periosteal pedicle for root coverage (Carvalho technique). A, Facial view of the prepared periosteal bed (P) with the exposed root. B, Dotted lines outline the design of the periosteal pedicle flaps. C, Pedicle raised, underlying bone exposed (B), and suturing begun. D, Single pedicle sutured in place. E, Use of two pedicles if the area is large. F, Graft positioned and sutured over the exposed root and periosteal pedicle flap.

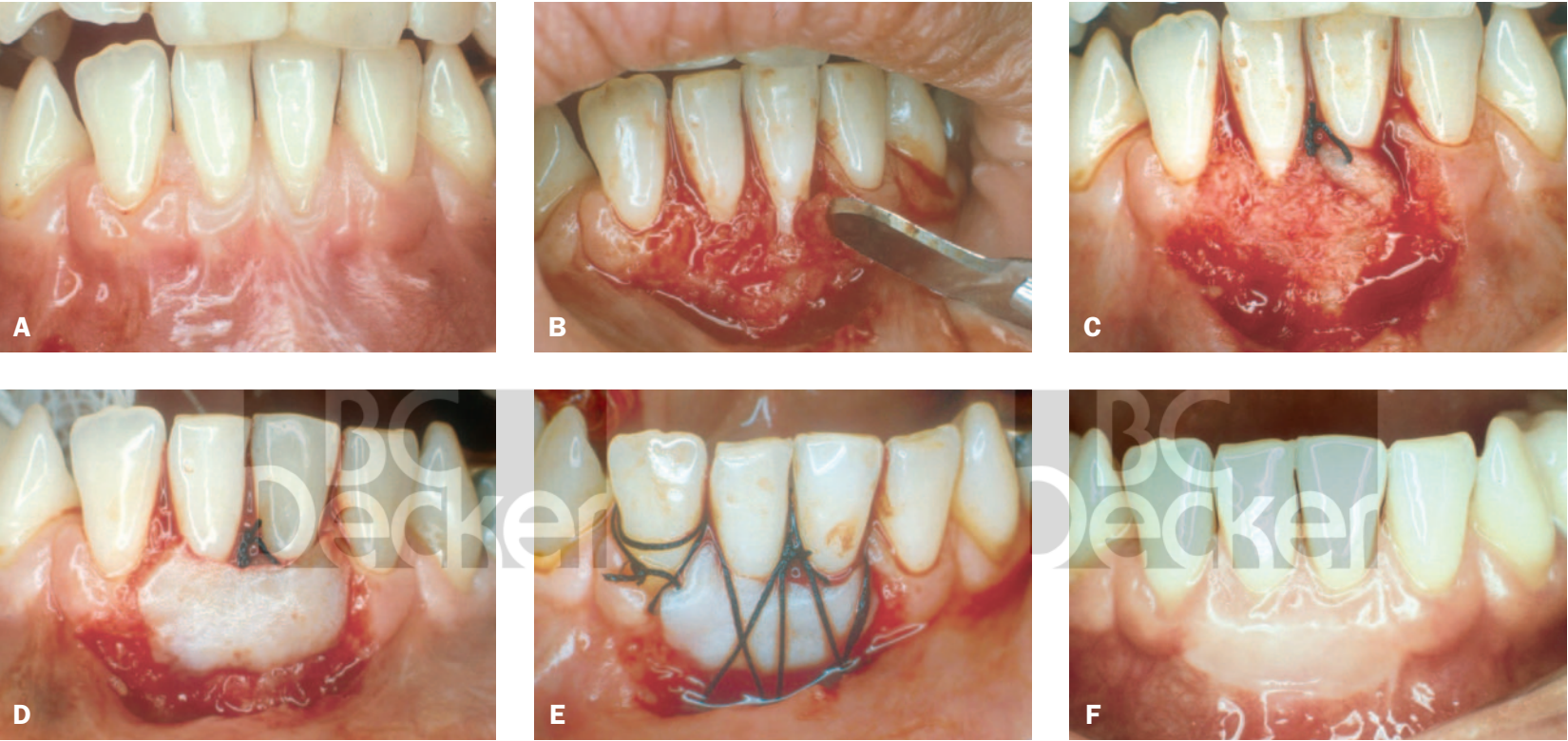


FIGURE 21-48. Free soft-tissue autograft with periosteal pedicle flap for root coverage. A, Before. Note recession on teeth on lower centrals. B, Periosteal pedicle flap reflected. C, Periosteal pedicle flap sutured. D, Graft placed. E, Graft sutured. F, One year later. Note root coverage and increased zone of attached gingiva. (From JC Carvalho, FE Putiglioni, and S Kon. Combination of a connective tissue pedicle flap with a free gingival graft to cover localized gingival recession. *Int J Periodont Rest Dent* 1982;4:27)

Most of these substitutes have found little acceptance owing to the fact that they

1. Antigenically complicated the healing process
2. Delayed healing
3. Lacked adequate predictability
4. Were too costly
5. Required multiple surgeries (Gore-Tex)
6. Were taken off the market (Guidor)

Recently, a new allographic acellular dermal matrix (ADM) was introduced and has gained widespread clinical acceptance. A number of clinical studies (Aichelmann-Reidy and colleagues, 1999, 2001; Harris, 1999, 2000, 2001, 2002; Henderson and colleagues, 2001; Mahn, 2001; Novaes and colleagues, 2001; Tal and colleagues, 2002) have shown that it is clinically effective and highly predictable (87–96%) and compares favorably with SCTGs.

Cores and colleagues (2004) and Woodyard and colleagues (2004) reported that gingival thickness and root coverage were significantly increased when AD is combined with a coronally positioned flap compared with a coronally positioned flap alone. Human histologic evidence (Cummings and colleagues, 2005) comparing ADM and autogenous connective tissue grafts under coronally positioned flaps demonstrated a thick dense band of collagenous tissue populated by normal cellular elements. Healing was by a long junctional epithelium, with the bone being unaffected. It was concluded that at 6 months, the healing between the two groups was similar.

Note: A more recent article (Harris, 2004) stating that the results of AD are not as maintainable over 5 years as those of SCTG may not be valid owing to case selection.

Advantages

1. Ease of handling
2. Handles similarly to connective tissue
3. Treats single or multiple sites
4. Highly predictable
5. Highly esthetic
6. Multipurpose use
 - a. Gingival augmentation
 - b. Root coverage
 - c. Socket preservation
 - d. Ridge augmentation
 - e. Guided tissue regeneration

The AD also meets the fundamental biologic requirements for a graft material:

1. Biocompatibility
2. Physiologic breakdown and removal
3. Immunologically inert

Potential Complications

1. Wound or systemic infection
2. Specific or nonspecific immune response.
3. Resorption of Alloderm
4. Nonintegration of the Alloderm acellular tissue regeneration tissue matrix into the host tissue

Hypersensitive allergic or other immune response to Alloderm has not been seen in pre-clinical and clinical trials. However, because Alloderm is composed of proteins, proteoglycans, and other components of human tissue, the potential exists for such reactions.

Material Specifications

AD is an aseptically prepared biocompatible graft material that acts as a biologic regenerative matrix or scaffold for the ingrowth of primordial undifferentiated mesenchymal and endothelial cells (7 days) (James and Klein, 1974). Because no gamma radiation is used and freeze-drying does not physically damage the collagen bundle structure or the basement membrane complex (at the light and electron levels) or the interstitial lysosaminoglycans, including hyaluronic acid and chondroitin sulfate, the collagen matrix and basement membrane complex are left intact (Livesey and colleagues, 1994; Wainwright and colleagues, 1994). It thus permits normal cell migration, repopulation (14–21 days), and incorporation and maturation (4–5 weeks) (Wainwright and colleagues, 1996).

It is important to note that turnover and replacement is by the fibroblast. There is no foreign body or giant cell reaction or residual by-products to interact, inhibit, or alter the normal biologic process of collagen production and removal.

ADM is also an immunologically inert material because it is cell free. It thus lacks the major histocompatibility complex class I and II antigens required for antigenicity, rejection, and inflammation and the cellular elements required for viral transmission (Livesey and colleagues, 1994) (Figure 21-49).

The *Annals of Periodontology* (2003) and the American Academy of Periodontology position paper on gingival recession (2005) support the use of ADM when combined with a coronal positioning for root coverage. They state: “The ability to cover an unlimited number of sites without the need for a second surgical site to obtain donor tissue is a significant advantage for this material.”

Graft Preparation: Rehydration Instructions

Alloderm grafts must be aseptically rehydrated for a minimum of 10 minutes but not more than 4 hours prior to use. Thicker grafts may take up to 40 minutes to rehydrate. Prewarming the saline to room temperature will facilitate rapid rehydration. (Figure 21-50)

Note: Do not heat saline above 37°C.

1. Necessary materials
 - Two sterile dishes (eg, kidney dishes)
 - Rehydration fluid: at least 100 mL of sterile normal saline or sterile lactated Ringer’s solution per Alloderm graft to be rehydrated
 - Sterile forceps
2. Preparing and rehydrating Alloderm grafts
 - Place the Alloderm graft, with attached backings, in the first dish in the sterile field. (Multiple grafts may be rehydrated simultaneously in the same dish.)

Note: Although not specifically recommended, Alloderm grafts may be aseptically trimmed to the approximate dimensions prior to rehydration.

Fill this dish with at least 50 mL of rehydration fluid for each Alloderm graft. Submerge the graft completely and allow it to soak for a minimum of 5 minutes. The two pieces of backing may float away from the tissue.

Using sterile gloves or forceps, remove and discard the backings. Aseptically transfer the Alloderm graft to the second dish and fill the dish with at least 50 mL of rehydration fluid for each graft. Submerge the graft completely and allow it to soak for at least 5 minutes. Thicker grafts may take up to 40 minutes to rehydrate. Prewarming the saline to room temperature will facilitate rapid rehydration. When the graft is properly rehydrated, it is soft and pliable. The fully rehydrated Alloderm graft is now ready for application to the surgical site.

Improper Rehydration

The cryoprotectants that enable freeze-drying of the dermis without structural damage may be toxic if exposed to cells in high enough concentrations. It has been determined that the Alloderm graft performs optimally if it is rehydrated for at least 10 minutes prior to use.

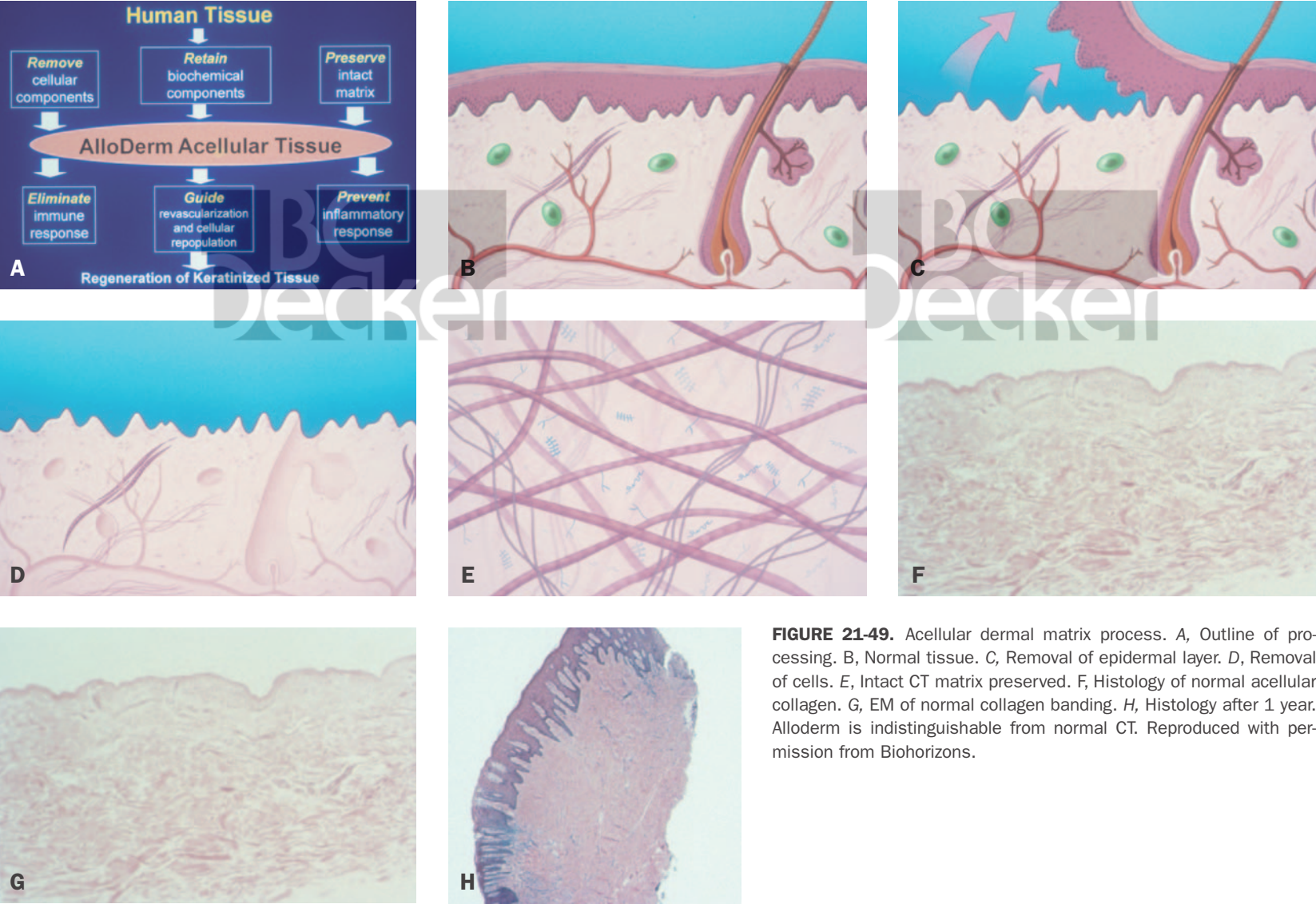


FIGURE 21-49. Acellular dermal matrix process. A, Outline of processing. B, Normal tissue. C, Removal of epidermal layer. D, Removal of cells. E, Intact CT matrix preserved. F, Histology of normal acellular collagen. G, EM of normal collagen banding. H, Histology after 1 year. AlloDerm is indistinguishable from normal CT. Reproduced with permission from Biohorizons.

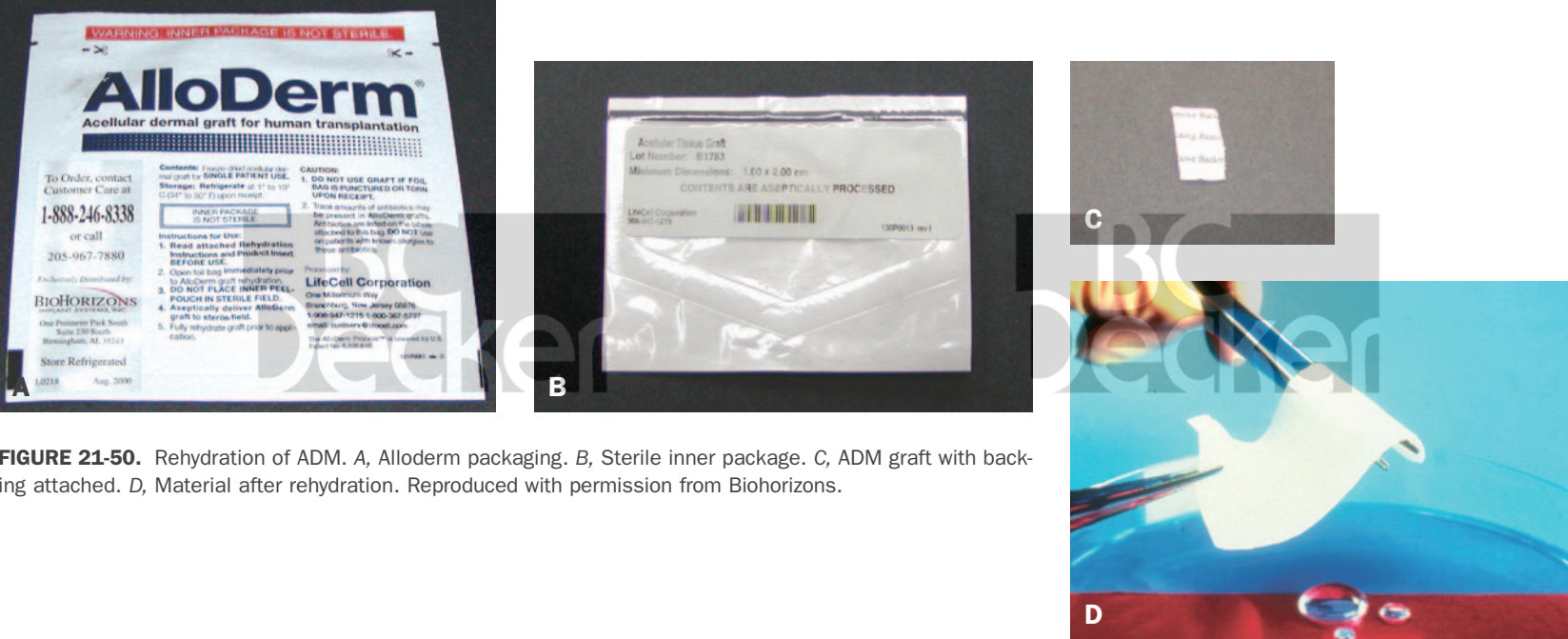


FIGURE 21-50. Rehydration of ADM. A, AlloDerm packaging. B, Sterile inner package. C, ADM graft with backing attached. D, Material after rehydration. Reproduced with permission from Biohorizons.

Placement of Alloderm

Application

- Using a sterile gloved hand or forceps, transfer the rehydrated Alloderm graft onto the prepared wound bed with the basement membrane either up or down. For correct orientation, the clinician must pay careful attention to the qualitative “physical” differences between the two sides. The correct orientation is determined by the following physical characteristics (Figure 21-51):
 - Dermal or connective tissue side: readily absorbs blood
 - Basement membrane side: does not readily absorb blood

The ability to absorb blood is the most important clinical differentiating factor. The other differences are more subjective in nature:

Dermal or connective tissue side

- More shiny or reflective
- More slippery or smooth
- Visually appears rougher

Basement membrane side

- More dull or nonreflective
- More rough by touch
- Visually appears smoother

Note: Although it has been shown that there is no difference in the results with orientation (basement lamina up or down), most clinicians still prefer placement of the basement lamina toward the tooth.

- After correct orientation has been achieved, the Alloderm graft may be further trimmed to the desired dimensions.
- Apply firm pressure on the Alloderm graft with a sterile, moist gauze pad for 3 to 5 minutes to adapt and adhere the graft to the recipient wound bed.

Surgical Procedure. There are actually two basic surgical techniques recommended for this procedure:

- Partial- or split-thickness flaps
- Full-split flap design

Note: The initial presurgical steps are similar and will be presented as such.

Initial Steps

- Presurgical control of inflammation
- Scaling and root planing (hand, ultrasonic, and rotary instruments)
- Chemical root preparation prior to surgery
 - Citric acid (pH 1.0)
 - EDTA (pH 7.0) is biocompatible and can be used after flap reflection
 - Tetracycline (100–125/mL)

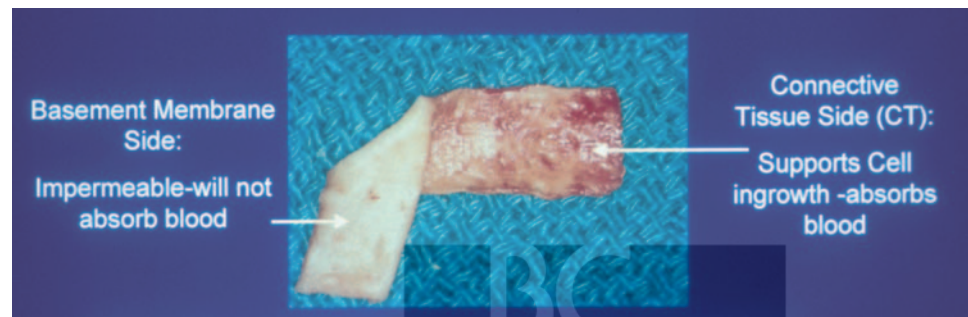


FIGURE 21-51. Tissue orientation. The basement lamina and connective tissue sides of the graft are demonstrated and differentiated. Reproduced with permission from Biohorizons.

- Measurements/bleeding points
 - CEJ to free gingival margin (“X”)
 - Measure “X” from the tip of the papilla
 - Place the bleeding point at the base of the “X” measurement

Note: The bleeding point will serve as the tip of a new papilla.

- A horizontal or scalloped interproximal incision is now made at the bleeding point(s). All of the interproximal points may be made prior to the sulcular incisions.

Note: Both procedures require split-thickness papillary incisions, preservation of the interproximal papilla, and deepithelialization for coronal positioning of the flap.

Partial- or Split-Thickness Flap (Allen, 1994a, 1994b; Harris, 2001; Novaes, 2001). All incisions are made supraperiosteal so that the periosteum is allowed to remain intact.

- The interproximal incisions are now carried onto the facial and connected.
- Vertical incisions are performed at the proximal ends of the flap.
- A partial-thickness flap is elevated by sharp dissection.
- If an envelope technique (no vertical incision) is used, the flap is extended one- to two teeth mesially and distally beyond the surgical site to ensure adequate flap mobility.

Note: Barros and colleagues (2004) demonstrated that when the flap is extended one tooth mesial and distal beyond the surgical site, there was a significant increase in root coverage.

- The remaining interproximal tissue is deepithelialized.
- The flap is undermined apically with a horizontal periosteal releasing incision far enough to ensure tension-free coronal positioning beyond the CEJ of the affected teeth.

- If there is any tension, then the flap requires greater release apically and or laterally.
- The area is measured and the material is trimmed, positioned, and sutured with 4-0, 5-0, or 6-0 chromic gut sutures.

Note: The AD is trimmed to overlap the bone by 3 to 4 mm and is carefully positioned at the CEJ. Exposure of the material may delay healing and compromise the final result. Coverage of the papilla with the material may result in flap slippage and material exposure. Dodge and colleagues (1998) developed a technique that permitted stable cervical placement of the material and interproximal exposure of tissue, permitting primary interproximal flap coaptation and total material coverage without flap slippage (see the following section).

- The flap is now coronally positioned and sutured with 4-0 or 5-0 chromic gut, 5-0 Vicryl, or 5-0 monofilament.
- Isobutyl cyanoacrylate (ISO-Dent, Ellman International) is now placed at the marginal areas (optional; recommended by Harris 2002)
- A periodontal dressing may or may not be applied (see Figures 21-52 and 21-53).

Mucoperiosteal Partial-Thickness Flap. All incisions are made to the osseous crest to permit a full-thickness flap to be elevated.

- The partial-thickness interproximal incisions are made down the buccal aspect of the osseous crest.
- The interproximal incisions are joined by the facial sulcular incisions.
- Vertical incisions are made mesial and distal to the affected teeth.
- A full-thickness flap is raised 3 to 4 mm beyond the osseous crest.
- An apical periosteal partial-thickness releasing incision is now made horizontally.

Note: The flap must be able to freely move coronally.

FIGURE 21-52. Multiple areas of extensive recession. A, Preoperative clinical view. B, Partial thickness flap. Note extensive recession. C, Graft positioned with basement lamina facing up. D, 5-0 vicryl sutures. E, Final result 1 year later.



6. The flap is coronally positioned and the tension is checked. It should be able to be positioned easily above the CEJ without tension.
7. The graft is positioned and trimmed to size (3 to 4 mm beyond the osseous crest).
8. Modified graft preparation technique (Dodge and colleagues, 1998; Henderson and colleagues, 2001)
 - a. The material is placed at the CEJ of the teeth.
 - b. The interproximal areas are noted and marked (small scissor or scalpel blade cuts).
 - c. A wedge of tissue is removed from all of the interproximal areas. This will ensure primary contact and healing between the flap and interproximal tissue. It will also avoid inadvertent interproximal coverage of the papillary tissue by the graft material.
 - d. The “tissue tabs” are now positioned facially at the CEJ.
 - e. Using a double suturing technique with 5-0 chromic gut or a 5-0 slow-resorbing, polyglyconate monofilament suture, the tabs are secured facially at the CEJ.
9. The flap is coronally positioned and sutured using a double-sling suture technique with 5-0 nonresorbable polybustier monofilament, 5-0 chromic gut, 5-0 Vicryl, or 5-0 Gore-Tex.

Note: Cyanoacrylate and/or periodontal dressing, although not recommended, may be used.

10. Postoperatively, the patient is asked to use an ultrasonic toothbrush with 0.12% chlorhexidine gluconate.

See Figures 21-54 to 21-56.

POSTOPERATIVE INSTRUCTIONS

1. Chlorhexidine gluconate 0.12%
2. Antibiotics
 - a. Doxycycline 50 mg once daily for 14 days or
 - b. Amoxicillin 50 mg three times daily 10 days
3. Analgesics as required
4. Dexamethasone 1 mg \times 18 (only when surgery is very extensive)
 - a. Days 1 to 3: 3 mg/d
 - b. Days 4 and 5: 2 mg/d
 - c. Days 7 to 9: 1 mg/d
5. Patients are usually seen weekly, with the sutures remaining for 2 weeks. This will provide greater flap stability and help prevent slippage.

Guided Tissue Regeneration, Ridge Augmentation, and Amalgam Tissue Tattoos. The ADM graft may be used for ridge maintenance during socket preservation or guided tissue regeneration.

In both instances, it is recommended that the basement lamina be positioned on the outer surface. It may also substitute for a SCTG in treating amalgam tattoos (Figures 21-56 to 21-58).

Tunnel Preparation for AD Placement (Mahn, 1999). The “tunnel” preparation has the following advantages:

1. Increased blood supply
2. Prevents flap slippage
3. Less material exposure

PROCEDURE

1. Vertical incisions are made at the terminal ends of the surgical site.
2. Coronally sharp dissection is used in the sulcus and papilla to help undermine the flap.
3. Apically and laterally, the flap is reflected with an Orban knife (periosteum retained) or periosteal elevator (full-thickness flap).
4. The AD graft is positioned under the flap and sutured with a 5-0 suspensory suture.
5. The flap is sutured using a 4-0 or 5-0 vertical or horizontal mattress suture to ensure complete root coverage. (Figure 21-60)

Note: Although ADM has been used for socket preservation and/or ridge preservation and guided tissue regeneration, these are supported only by individual case reports, and further study is required.

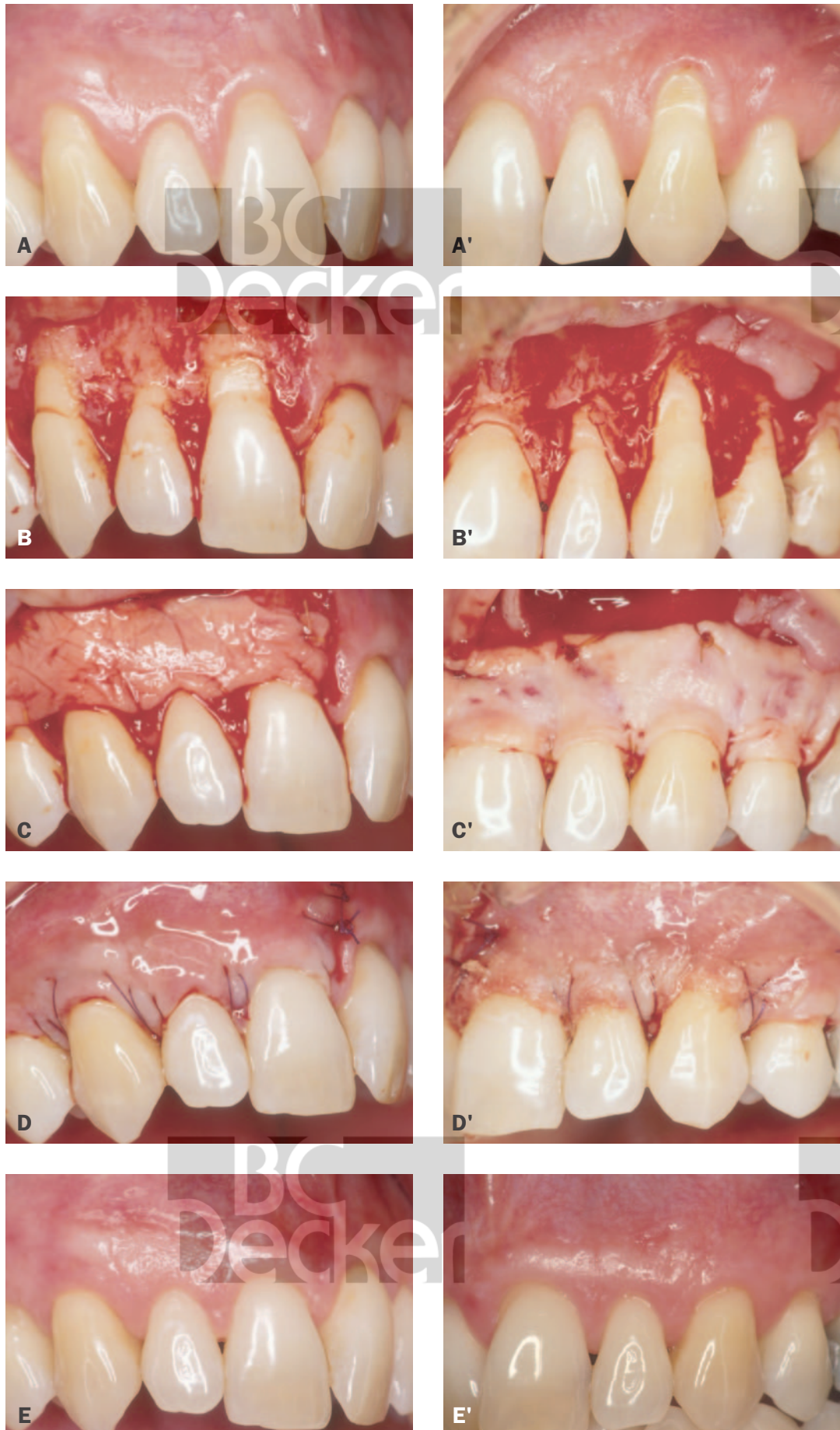


FIGURE 21-53. ADM for treatment of multiple teeth on the same patient treated at different times. A, A', Preoperative view with significant recessions on teeth #6-12. B, B', Partial thickness (periosteum retained) flaps reflected. C, C', ADM positioned with basement lamina up (C) and down (C'). D, D', Flaps coronally positioned and sutured with 5-0 Vicryl sutures. E, E', Final healing 10 months later with excellent clinical results.



FIGURE 21-54. Basic procedure. A, Preoperative view. B, Partial thickness flap raised. Note extensive recession. C, Material prepared for placement. Dodge modifications. D, Material positioned; two pieces – 1 basement lamina down, 1 connective tissue down (dodge suture modification.)



FIGURE 21-55. Maxillary anterior teeth with extensive recession. *A, A'*, Preoperative clinical view. *B, B'*, Graft positioned with basement lamina down and dodge technique used. *C, C'* 5-0 Vicryl used for flap fixation. *D, D'*, Final result.



FIGURE 21-56. Maxillary anterior teeth with extensive recession. A, B, Facial and lateral views showing multiple areas of recession. C, Acellular dermal matrix sutured. D, Dodge continuous suturing technique. E, Flaps coronally positioned and sutured. F, 10 months later with 100% root coverage.



FIGURE 21-57. Alloderm for ridge augmentation. A, Initial view. Note unsightly smile line. B, Close-up view of teeth to be extracted #7-10. C, Atraumatic extraction. D, DFDBA placed. E, Alloderm positioned with CT portion facing down. F, Primary closure achieved. G, 4 months after surgery. H, Gingivoplasty for ovate pontic temporaries. I, Temporary bridge after healing. J, Final pontic form established in ridge. K, Final prosthetic bridge. L, Final smile. Compare to Figure A. (Prosthetics courtesy of Dr. Richard Rossman, Randolph, MA.)

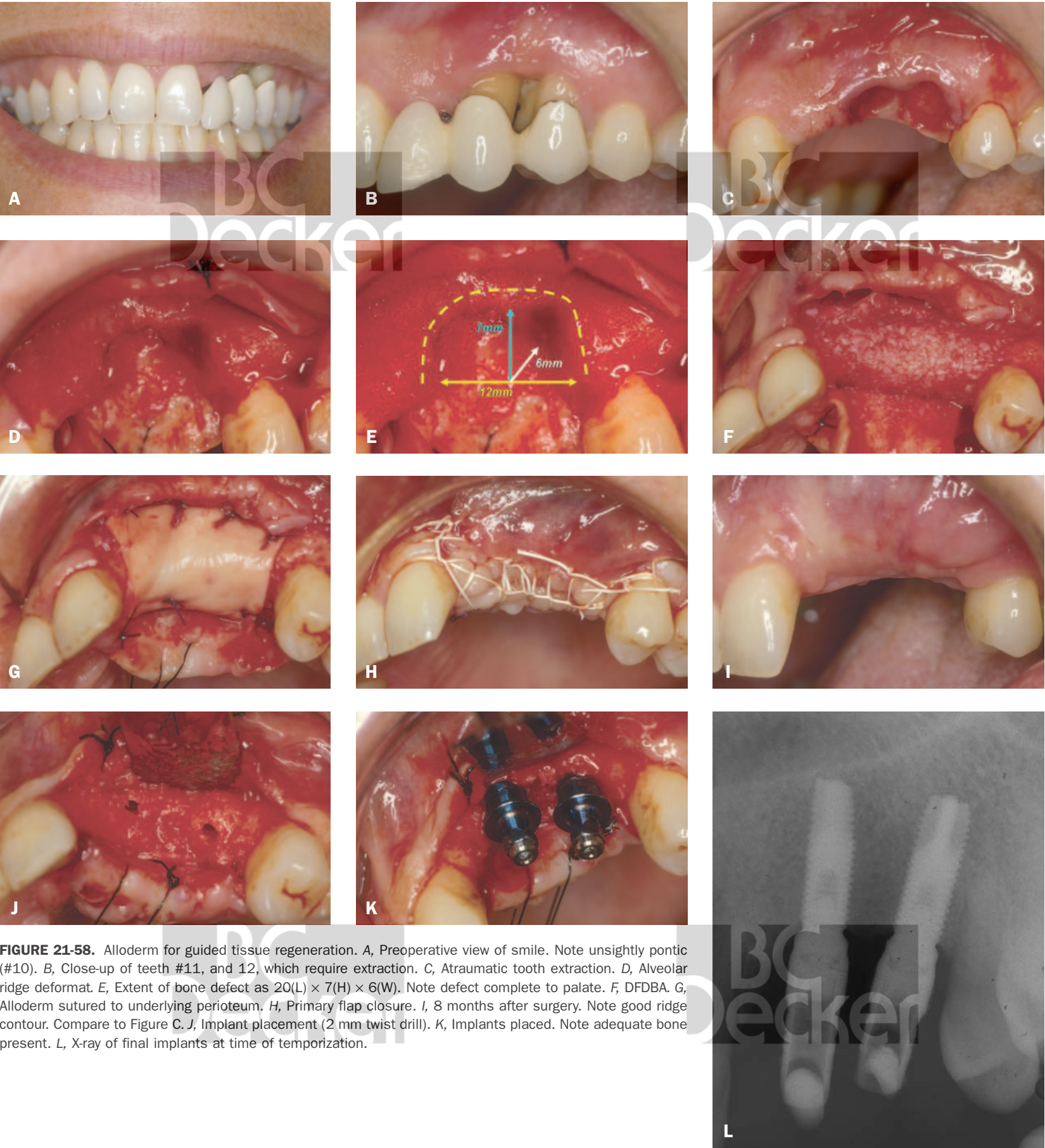


FIGURE 21-58. Alloderm for guided tissue regeneration. *A*, Preoperative view of smile. Note unsightly pontic (#10). *B*, Close-up of teeth #11, and 12, which require extraction. *C*, Atraumatic tooth extraction. *D*, Alveolar ridge deformity. *E*, Extent of bone defect as 20(L) × 7(H) × 6(W). Note defect complete to palate. *F*, DFDBA. *G*, Alloderm sutured to underlying periosteum. *H*, Primary flap closure. *I*, 8 months after surgery. Note good ridge contour. Compare to Figure *C*. *J*, Implant placement (2 mm twist drill). *K*, Implants placed. Note adequate bone present. *L*, X-ray of final implants at time of temporization.

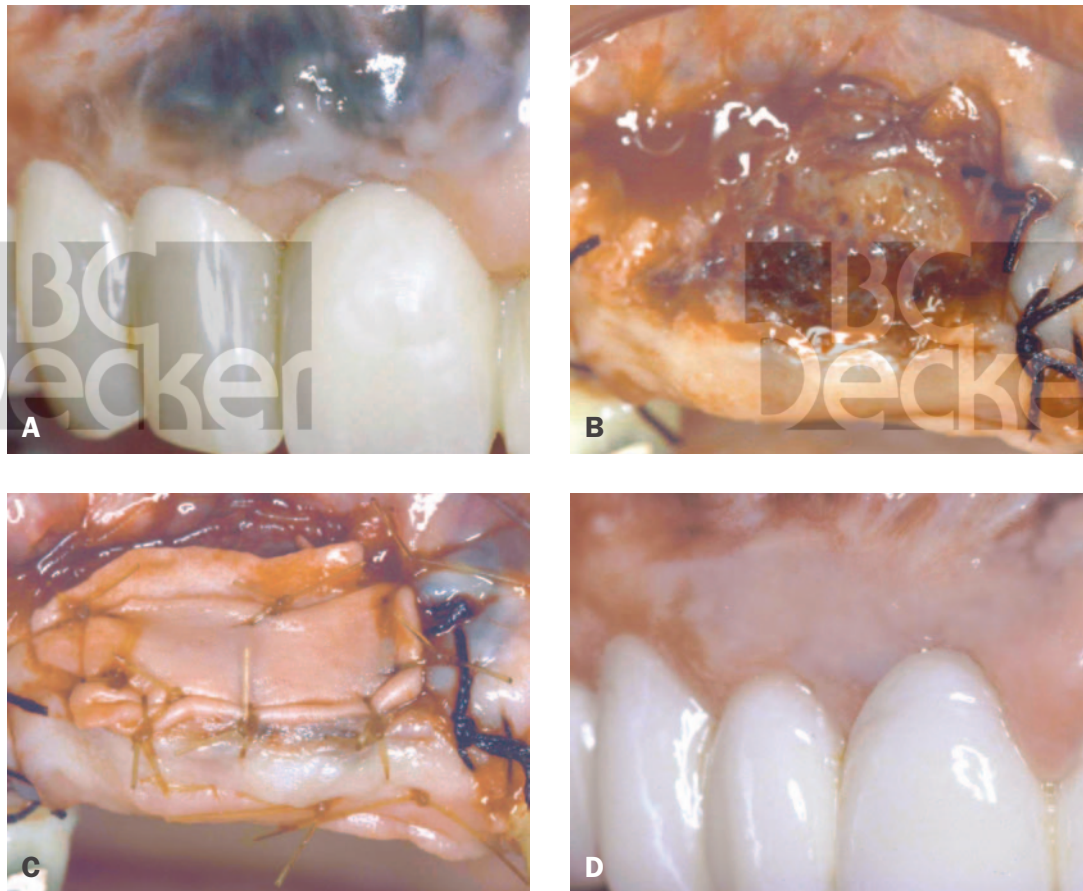


FIGURE 21-59. Treatment of amalgam tattoo with Alloderm. *A*, Preoperative view of large amalgam tattoo. *B*, Periosteal bed prepared. *C*, Allographic dermal matrix sutured to position. *D*, Final result. Note complete removal of unsightly tattoo.



FIGURE 21-60. Tunnel preparation and ADM for root coverage. *A* and *B*, Facial and lateral views showing significant areas of recession. *C*, Periodontal probe in position showing tunnel preparation. *D*, Diagrammatic view of suturing technique. *E* and *F*, Facial and lateral views of final suturing. *G*, Final case 6 months later. Compare to *A* and *B*.

Ridge Augmentation

Excessive bone resorption is commonly found when teeth are extracted. This is a problem anteriorly because it will result in an unesthetic long pontic on a narrow, hollowed-out ridge. Special techniques have been developed to treat problems of vertical and horizontal ridge resorption.

Classification of Ridge Defects

Seibert (1983) classified the various types of ridge loss into three classes:

Class I: buccolingual loss of tissue with normal ridge height in the apicocoronal dimension (Figure 22-1)



FIGURE 22-1. Class I ridge loss.



FIGURE 22-2. Class II ridge loss.



FIGURE 22-3. Class III ridge loss.

Class II: apicocoronal loss of tissue with normal ridge width in a buccolingual dimension (Figure 22-2).

Class III: combination buccolingual and apicocoronal loss of tissue, resulting in loss of normal height and width (Figure 22-3)

Full-Thickness Soft Tissue Grafts

Meltzer (1979) published the first clinical report on using a soft tissue graft solely to correct an

esthetic anterior vertical ridge defect. Seibert (1983a, 1983b) published a series of classic articles that detail the technique and its application. Figures 22-4 and 22-5 show the clinical application of the technique. Note in Figure 22-5G that after the epithelial denudation is complete, vertical slices are made to enhance the bleeding surface. This is to permit adequate diffusing of the full-thickness graft. The tuberosity or dentulous ridge is the best source for donor tissue. The procedure is limited by the availability of thick, graftable tissue.



FIGURE 22-4. Free gingival onlay graft for correction of a Class III ridge defect. A, Pretreatment view of an extensive Class III ridge defect. The patient has used a removable prosthesis for many years and wished to have a fixed prosthesis made. B, First stage of soft tissue reconstruction. A large, thick onlay graft was sutured into position. C, Two months postsurgery. The onlay graft produced gain in ridge height. A second procedure was performed to augment the ridge further in the buccolingual dimension. D, A veneer type of free graft was used to gain augmentation in a buccolingual direction. E, Appearance of the reconstructed ridge 2 months after the final grafting procedure. Compare the contour of the healed augmented ridge with that shown in Figure 10-4A. F, Provisional prosthesis in place. Courtesy of Dr. Jay Seibert, Philadelphia, PA.

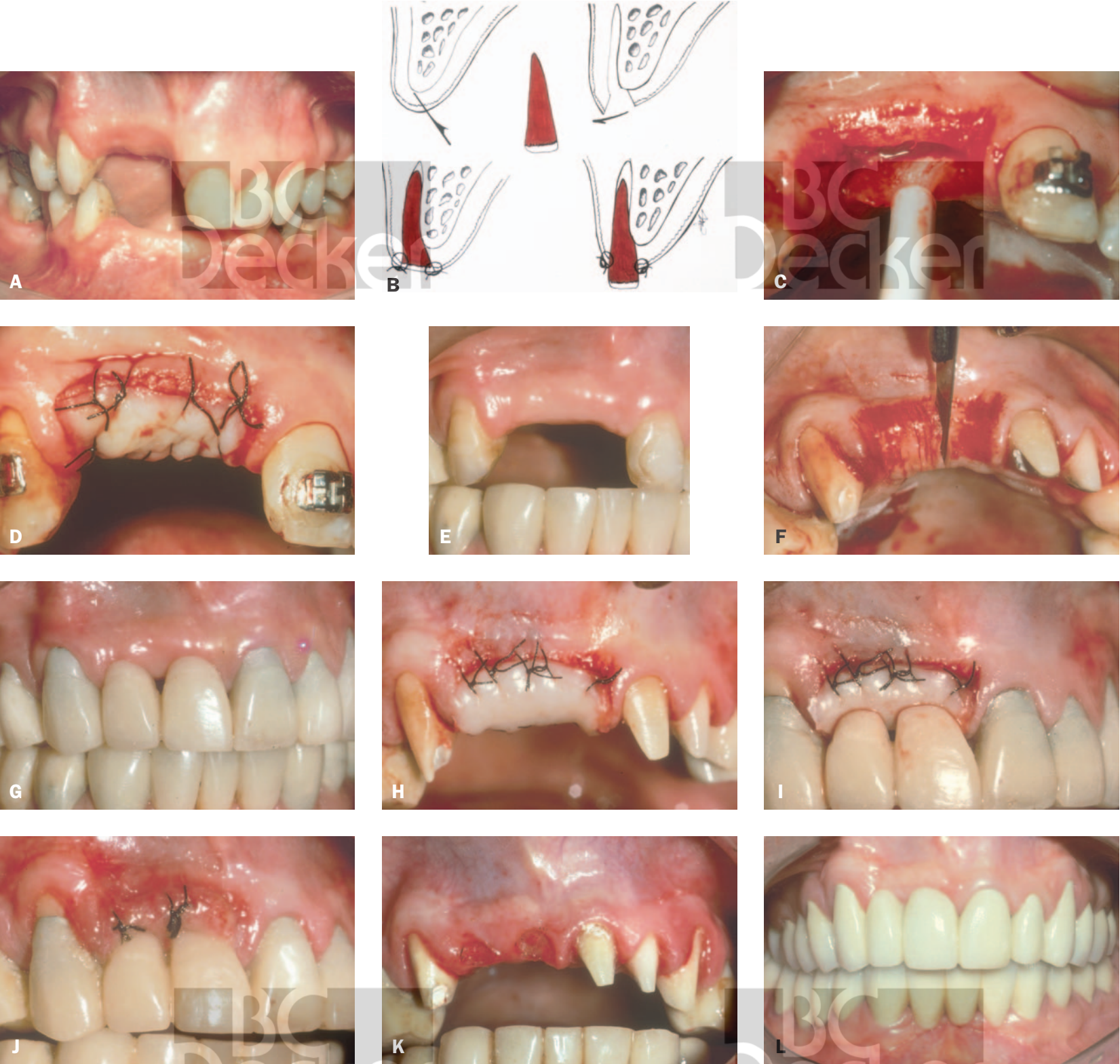


FIGURE 22-5. Interpositional graft procedure in conjunction with second-stage onlay graft for correction of a Class III ridge defect. *A*, Pretreatment view. The patient had a large Class III ridge defect. *B*, Sequence of steps in the wedge procedure. A wedge-shaped section of connective tissue with its epithelium was removed from the palate and inserted between the elevated pouch-like flap and the ridge. *C*, The pouch was prepared to receive the wedge (inlay-onlay) graft. *D*, The graft was sutured into position. *E* and *F*, Two months postsurgery. Note the amount of ridge height that was obtained. A second-stage procedure was performed to gain more ridge height and to fill in the “dark triangles” between the teeth. *G*, Two months after the first surgical procedure, the ridge was deepithelialized and cuts were made into the connective tissue prior to placing the second-stage onlay graft into position. *H*, The onlay graft was sutured into position. *I*, The pontics were adjusted and brought into light contact with the graft. *J*, Marked swelling occurred within the graft 14 days postsurgery. *K*, Two months following the second surgical procedure, gingivoplasty was performed to deepen the pontic sites for the ovate pontics. *L*, Post-treatment view 1 year after the final surgical procedure. Courtesy of Dr. Jay Seibert, Philadelphia, PA.

Pouch Procedure

Garber and Rosenberg (1981) developed a technique for treating ridges that had a horizontal loss of dimension. Using a connective tissue graft from the tuberosity for subepithelial placement, the procedure provides both stabilization of the graft and ridge enhancement. This technique was a refinement and an advancement of those devised by Langer (1980) and by Abrams (1980).

Figure 22-6A shows an occlusal view of the initial horizontal incision made at the crest of the ridge. A partial-thickness incision is made with a no. 15 scalpel blade and extended apically and laterally over the deformity (Figure 22-6B). Blunt dissection may be used to extend the pouch.

The connective tissue graft is sutured using 4-0 or 5-0 silk or gut. The suture is passed first through the base of the pouch (Figure 22-6C).

This provides apical stabilization of the graft. Figure 22-6D shows the addition of a second middle suture and closure of the initial horizontal incision. Figure 22-6E is an occlusal view of the graft sutured showing the correction of the deformity. Figure 22-6F is a cross-sectional view of the graft stabilized in position.

This procedure is shown clinically in Figures 22-7 to 22-9.

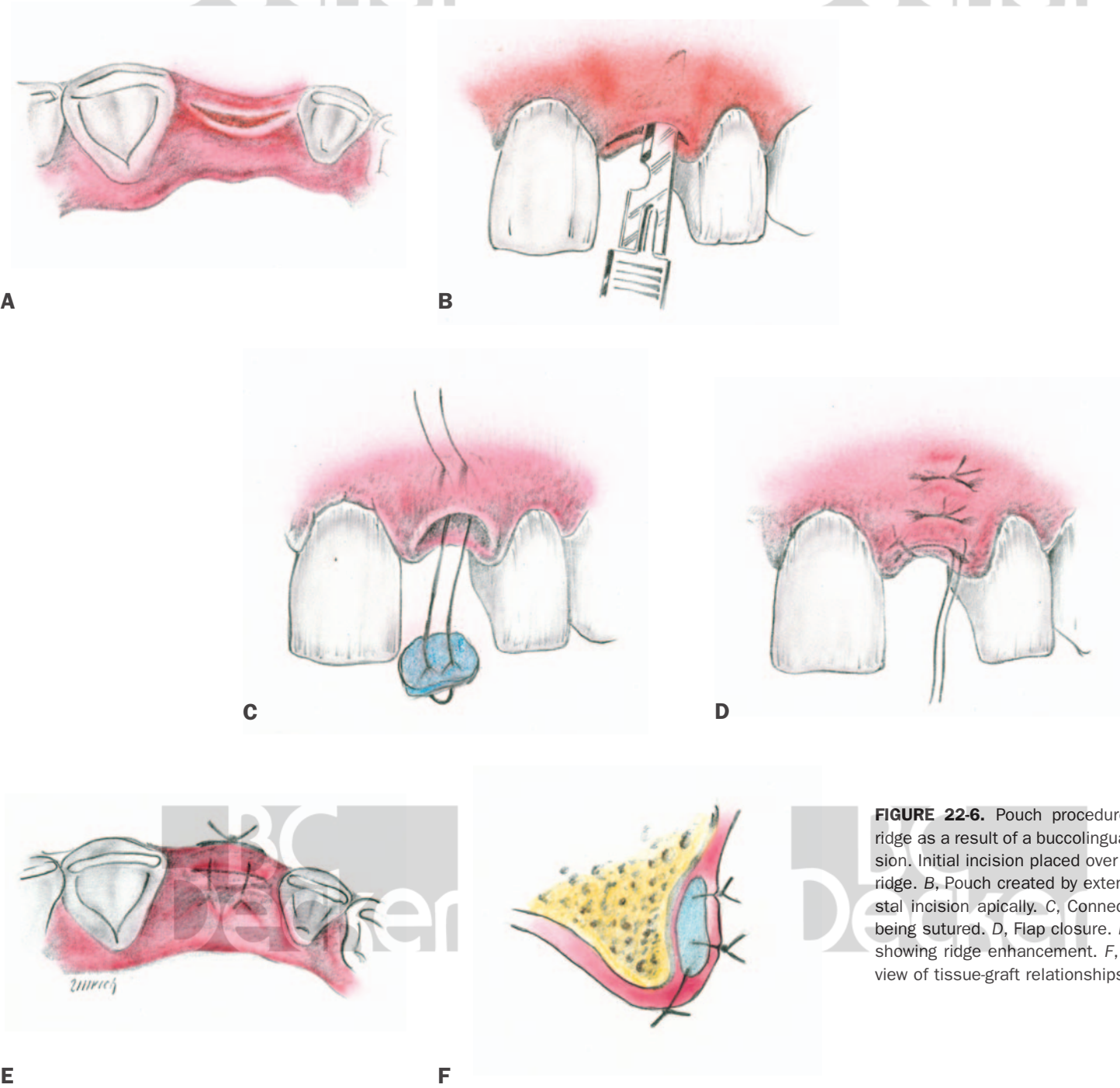


FIGURE 22-6. Pouch procedure. A, Deformed ridge as a result of a buccolingual loss in dimension. Initial incision placed over the crest of the ridge. B, Pouch created by extension of the crestal incision apically. C, Connective tissue flap being sutured. D, Flap closure. E, Occlusal view showing ridge enhancement. F, Cross-sectional view of tissue-graft relationships.

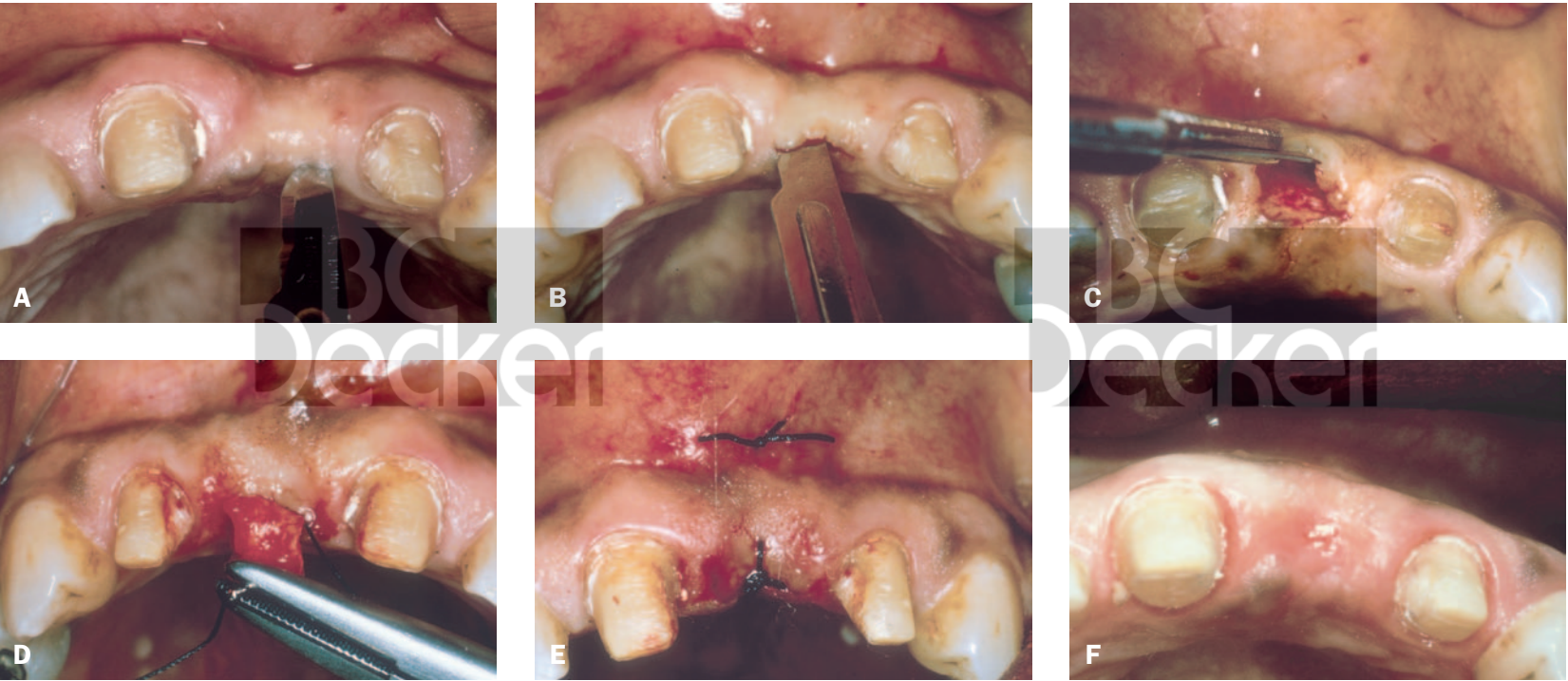


FIGURE 22-7. Pouch procedure for ridge augmentation. A, Before, as the incision is to begin. Note horizontal loss of ridge dimension. B, Horizontal ridge incision begun. C, Pouch formed. D, Connective tissue graft being placed and sutured. E, Graft placed and pouch sutured. F, Three months later. Note restoration of the ridge. Reproduced with permission from Garber D, Rosenberg E. The edentulous ridge in fixed prosthodontics. *Compend Contin Educ Gen Dent* 1981;2:212.

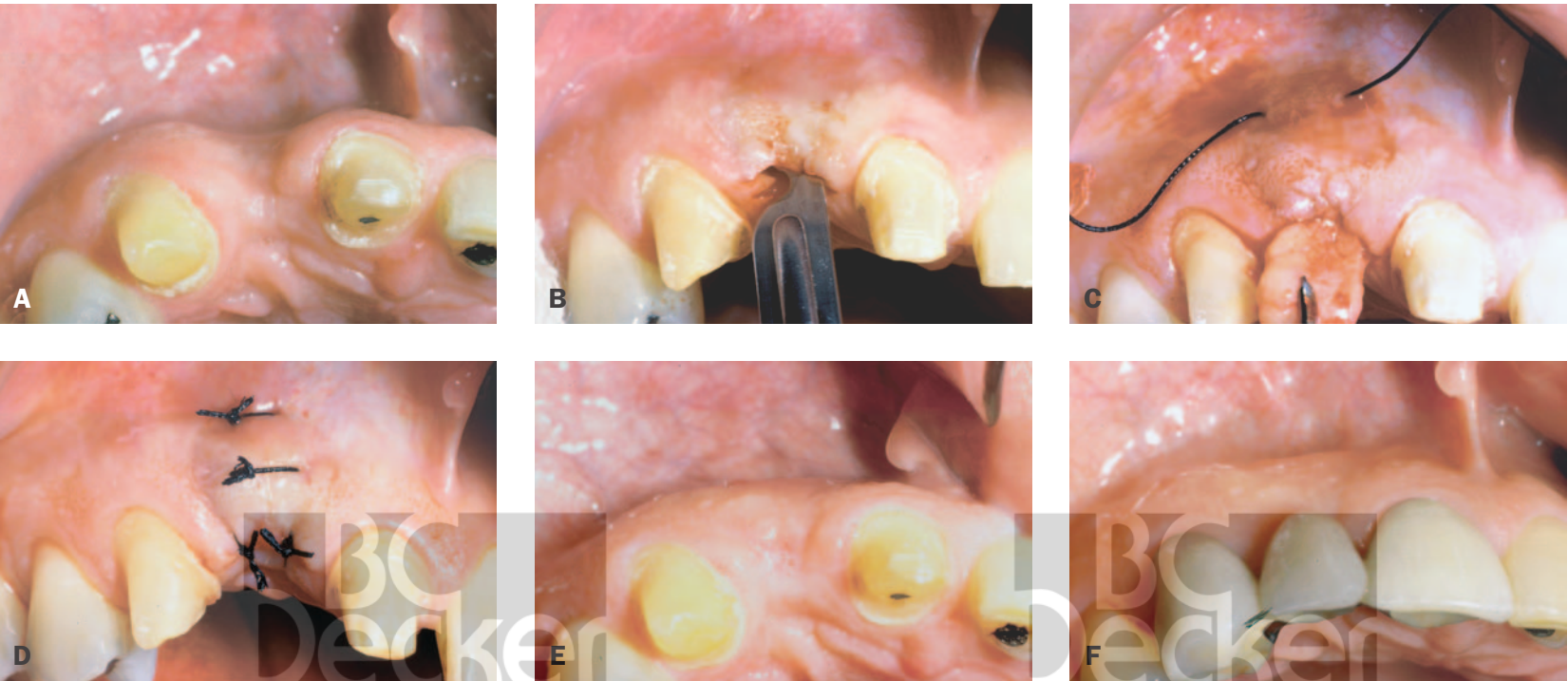


FIGURE 22-8. Pouch procedure. A, Before treatment; Class I ridge deformity. B, A horizontal ridge incision is made. C, Connective tissue graft being placed and sutured. D, Graft placed and sutured. E, Two months later. Note correction of the buccal deformity. F, Final prosthetics.



FIGURE 22-9. Buccal ridge enhancement at the time of implant exposure. A and B, Buccal and occlusal views prior to implant exposure with significant buccal concavity. C, The present concave contour and the desired final convex form. D, Implant exposed with conservative occlusal surgery, buccal partial-thickness pouch completed, and connective tissue graft inserted and stabilized. E, Buccal view. Note that the esthetic gingival contour has not been compromised. F, Final healing prior to prosthetics with complete restitution of buccal eminence.

Ridge Augmentation— Improved Technique

In 1985, Allen and colleagues outlined an improved surgical technique for localized ridge augmentation that was similar to that previously described by Kaldahl and colleagues (1982) except that the graft material was a hydroxyapatite implant.

The use of a hydroxyapatite implant permitted an unlimited donor source, with greater predictability of results. The use of a partial-thickness palatal flap prevents separation and opening of the pouch.

Procedure

In Figure 22-10, A and B, the flap is outlined. Two partial-thickness vertical parallel incisions are joined by a horizontal incision. The incisions are begun 6 to 12 mm palatal to the crest of the ridge. Care is taken to avoid the sulci of the adjacent teeth. The partial-thickness flap will extend to the crest of the ridge.

A partial-thickness flap is raised using sharp dissection to the crest of the ridge (Figure 22-10C).

At the crest of the ridge, a full-thickness pouch is reflected off the bone and extended far enough apically for correction of the ridge defor-

mity (see Figure 22-10C and 22-10D). The pouch is now filled with any of the hydroxyapatite or allographic materials, nonresorbable as seen in Figure 22-10, E and F.

The pouch is closed, and the flap is sutured. Even if the flap is not totally approximated palatally, it will still not open because of the adequate overlap of the tissue palatally (Figure 22-10F). The procedure is depicted clinically in Figure 22-11.

Note: This procedure, although successful, has been supplemented by the subepithelial connective tissue ridge modifications.



FIGURE 22-10. Ridge augmentation: improved technique. *A*, Palatal view, with initial incisions outlined. *B*, Cross-sectional view showing partial-thickness design of flap to crest of ridge. *C*, Flap reflected and pouch formed. *D*, Cross-sectional view of partial full-thickness pouch design. *E*, Hydroxyapatite placed in pouch. *F*, Cross-sectional view of filled pouch. *G*, Pouch sutured and closed.



FIGURE 22-11. Ridge augmentation improved technique. *A*, Preoperative clinical view showing modified ridge lap pontics with collapsed (CLI) ridge. *B*, Occlusal view. *C*, Palatal view. Note that they begin 10-15 mm palatal to the ridge and avoid the sulcus area. *D*, Partial-thickness palatal flap and full-thickness pouch reflected. *E*, Hydroxyapatite graft placed. *F*, Flap sutured. *G* and *H*, Final occlusal and prosthetic views. Note that the pontics have been cut back to accommodate the expanded ridge form.

Subepithelial Connective Tissue Graft for Ridge Augmentation

Langer and Calagna (1980, 1982) designed a procedure for ridge augmentation that uses a combination of a partial-thickness flap (buccally and palatally) and a connective tissue graft.

Advantages

- 1. Versatility
- 2. Primary closure
- 3. Good vascularity
- 4. May be combined with adjacent root coverage procedures
- 5. Reduced trauma

Disadvantages

- 1. Technically difficult
- 2. Possible need for secondary mucogingival surgery owing to altered coronal position of the mucogingival junction

Indication

- 1. For correction of all types of ridge deformities

Procedure

- 1. With a no. 15 c scalpel blade, a partial-thickness flap is begun at the crest or palatal to the crest of the edentulous ridge (only if a flap overlap is desired) (Figure 22-12A).
- 2. The incisions are carried mesially and distally to the terminal ends of the edentulous ridge (Figure 22-12B).
- 3. Vertical incisions are now made buccally and palatally. Buccally, they are carried far enough apically beyond the mucogingival junction to permit freedom of movement. Palatally, the flap is reflected just far enough to permit placement of the graft (see Figure 22-12A).

- 4. A horizontal apical releasing incision of the buccal flap may be necessary for greater flap mobility and coronal positioning (Figure 22-12C).
- 5. The connective tissue grafts (see Ch. 21, "Reconstruction"), without the epithelial borders, are sutured in place using chromic gut sutures. One or more pieces may be used depending on the defect (Figure 22-12, D and D').
- 6. The buccal flap is coronally positioned and sutured at the crest of the ridge or overlapped palatally. The flap is also sutured laterally for enhanced stability (Figure 22-12E).

The clinical procedure is depicted in Figures 22-13 to 22-18.

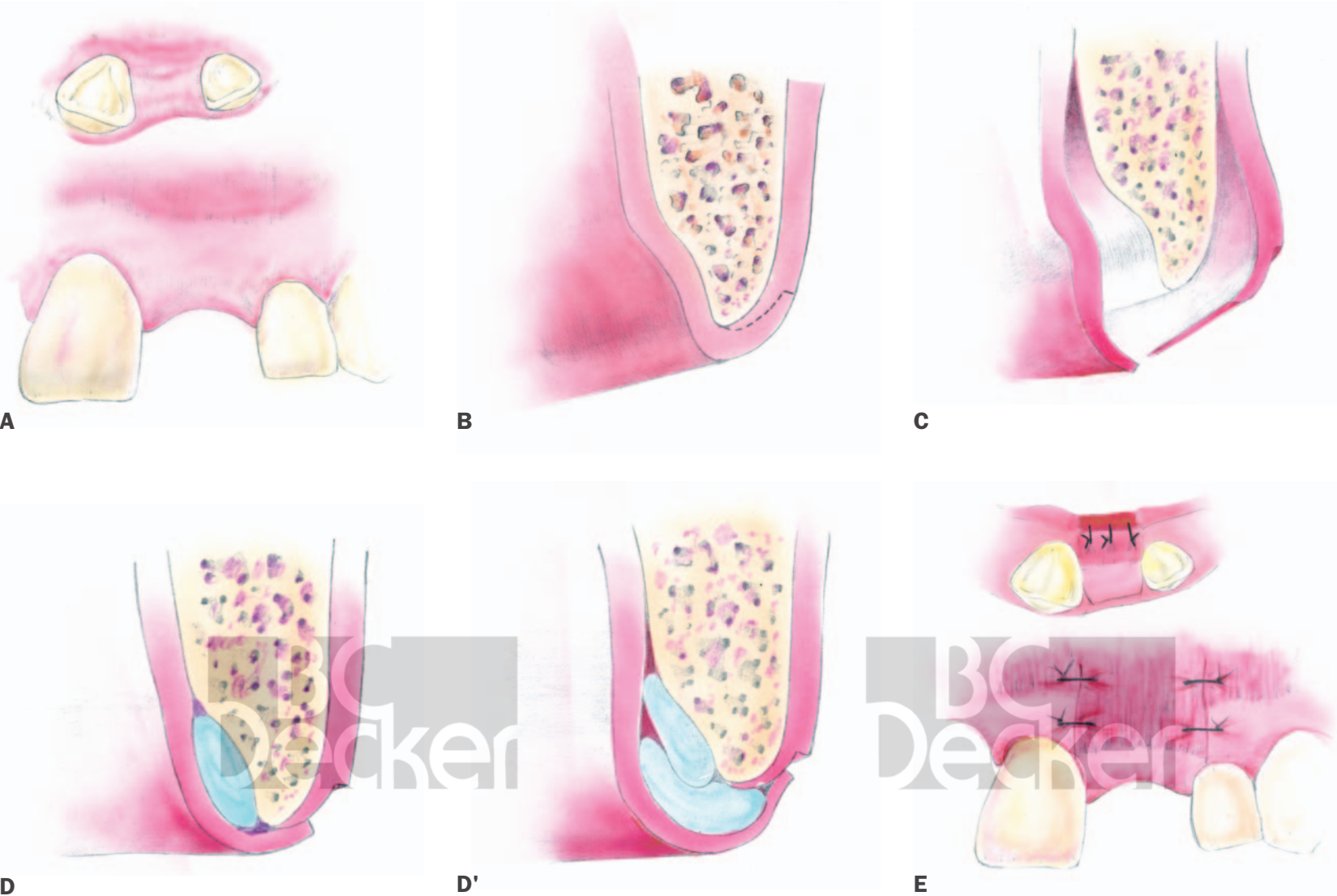


FIGURE 22-12. Subepithelial connective tissue graft for ridge augmentation. A, Incisions outlined buccally. B, Palatal partial-thickness flap raised to ensure overlap. C, Partial-thickness flaps reflected. D, Single connective tissue graft placed. D', Alternatively, multiple connective tissue grafts placed. E, Final suturing. Note coronal movement of mucogingival function.

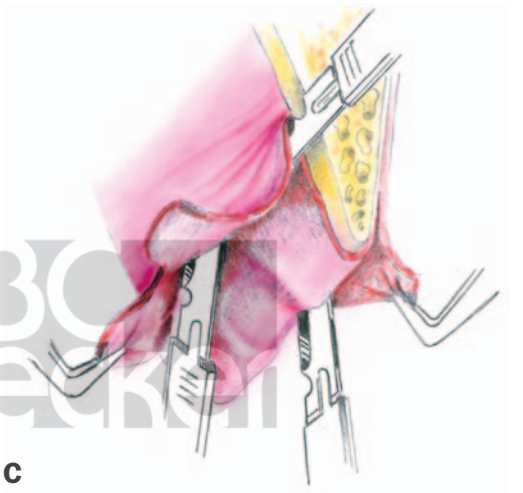
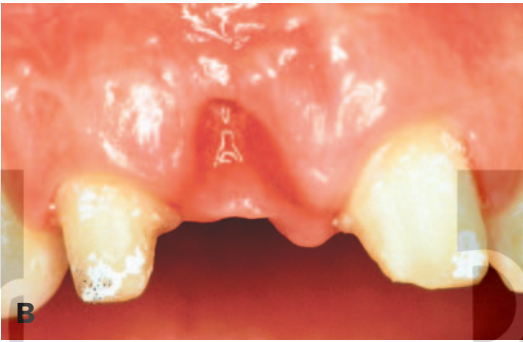
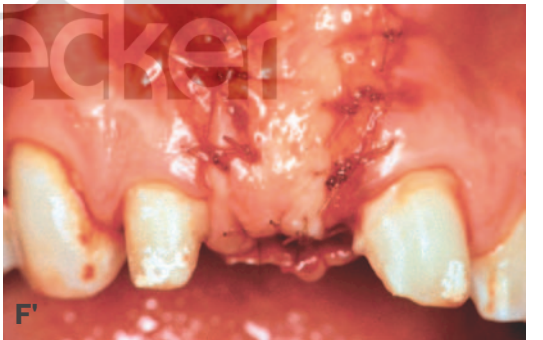
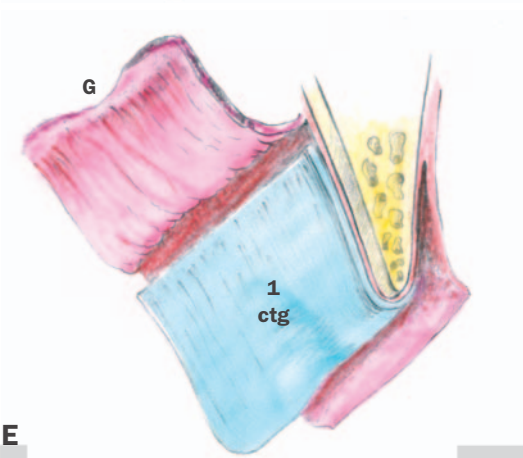
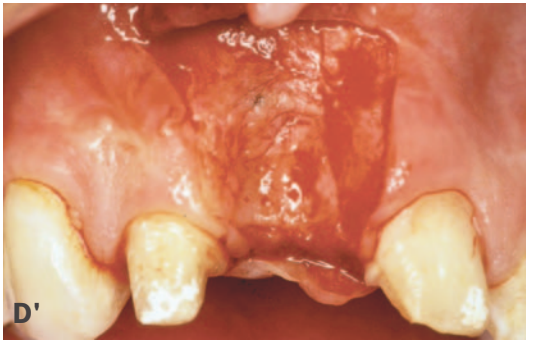
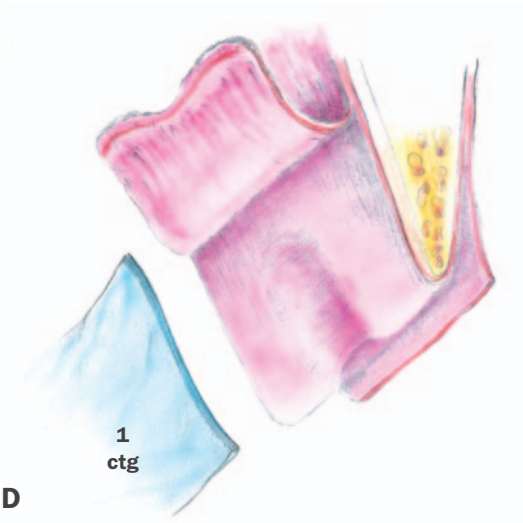


FIGURE 22-13. Ridge augmentation: subepithelial connective tissue graft. *A* and *B*, Preoperative clinical view of an unesthetic long crown and underlying Class I-II ridge defect. *C*, Diagrammatic and clinical representation of buccal partial-thickness flaps being reflected. *D* and *D'*, Partial-thickness flaps reflected and the defect exposed. *E* and *E'*, First connective tissue graft placed and stabilized to the underlying periosteum. *F* and *F'*, Second connective tissue graft placed and stabilized to both the first connective tissue graft and the periosteum.



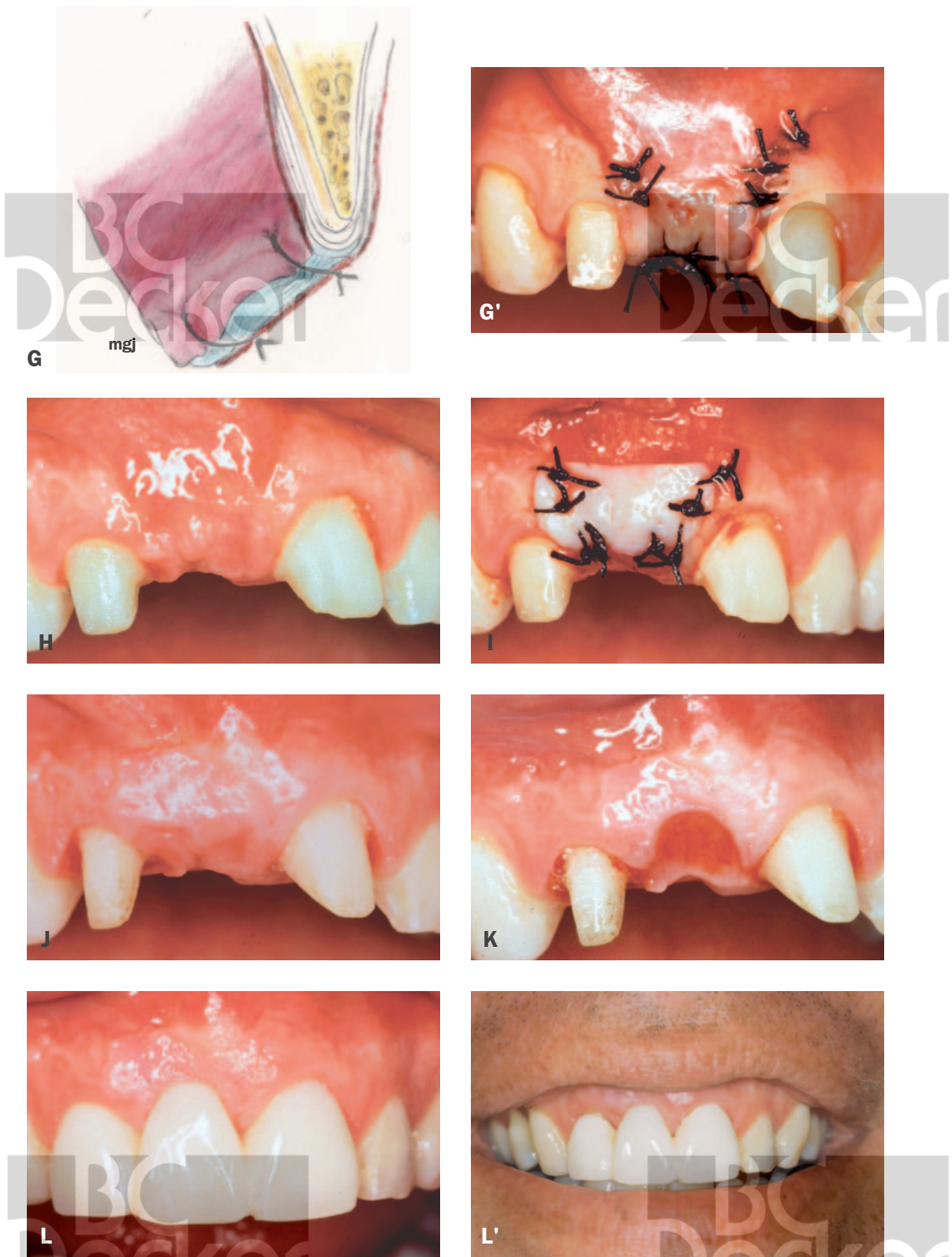


FIGURE 22-13. Continued. *G* and *G'*, Flaps are coronally positioned and sutured. *H*, Ridge corrected, but there is inadequate keratinized gingiva. *I*, Free gingival graft for increasing the zone of keratinized gingiva. *J*, Ridge completely restored. *K*, Ovate pontic used to develop the ridge contour and papilla. *L* and *L'*, Final esthetic result showing excellent gingival symmetry and papillary development.

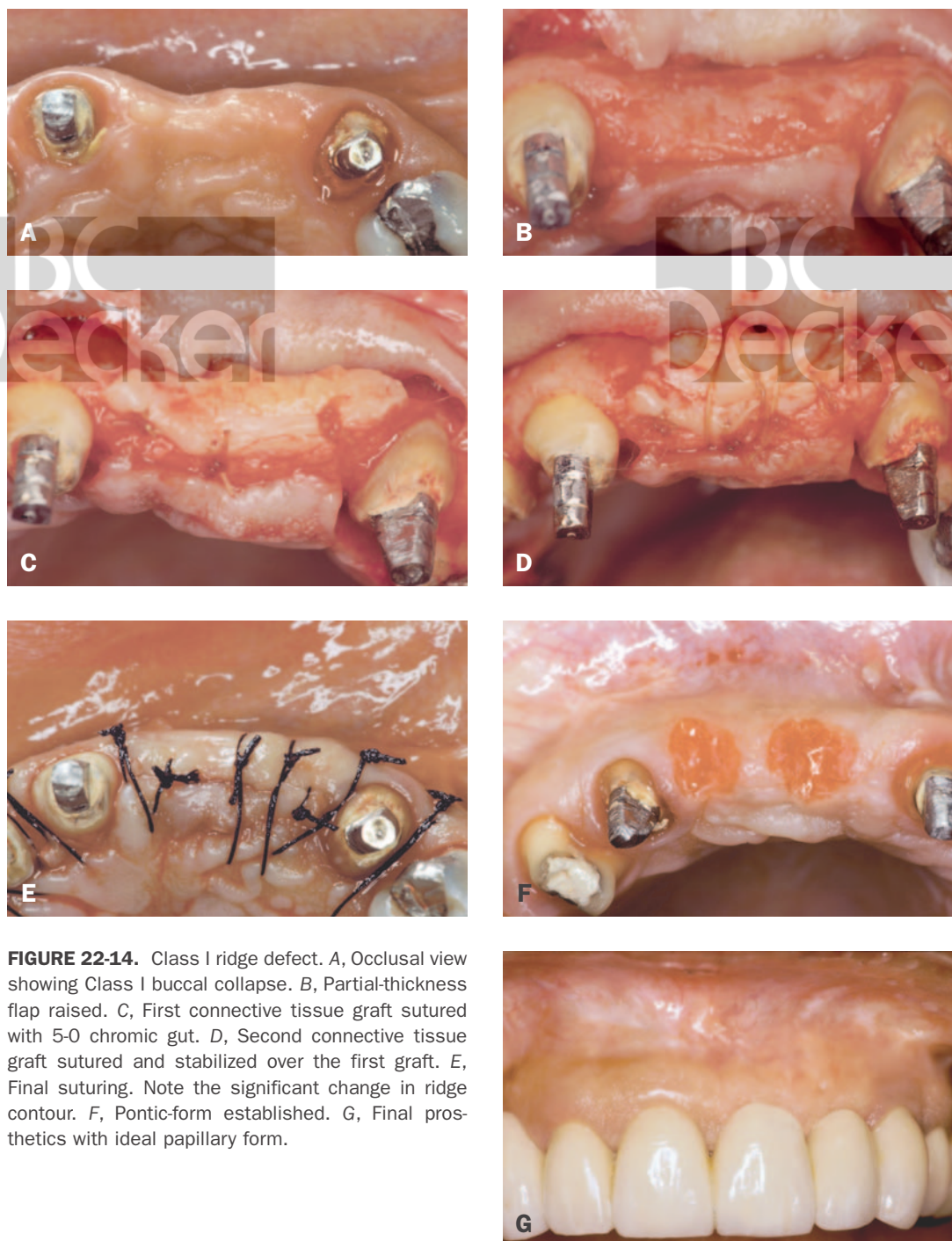


FIGURE 22-14. Class I ridge defect. A, Occlusal view showing Class I buccal collapse. B, Partial-thickness flap raised. C, First connective tissue graft sutured with 5-0 chromic gut. D, Second connective tissue graft sutured and stabilized over the first graft. E, Final suturing. Note the significant change in ridge contour. F, Pontic-form established. G, Final prosthetics with ideal papillary form.



FIGURE 22-15. Class II ridge augmentation. A and B, Initial view showing unsightly long crowns. C, Class II ridge defect, 13 × 5 mm. D, First onlay connective tissue graft. Note that the papilla adjacent to the teeth are left untouched to ensure maximum graft height. E, Second onlay connective tissue graft. F, Healing at 3 months. Note complete restoration of the ridge height. G and H, Temporization of all teeth. Compare with A and B.

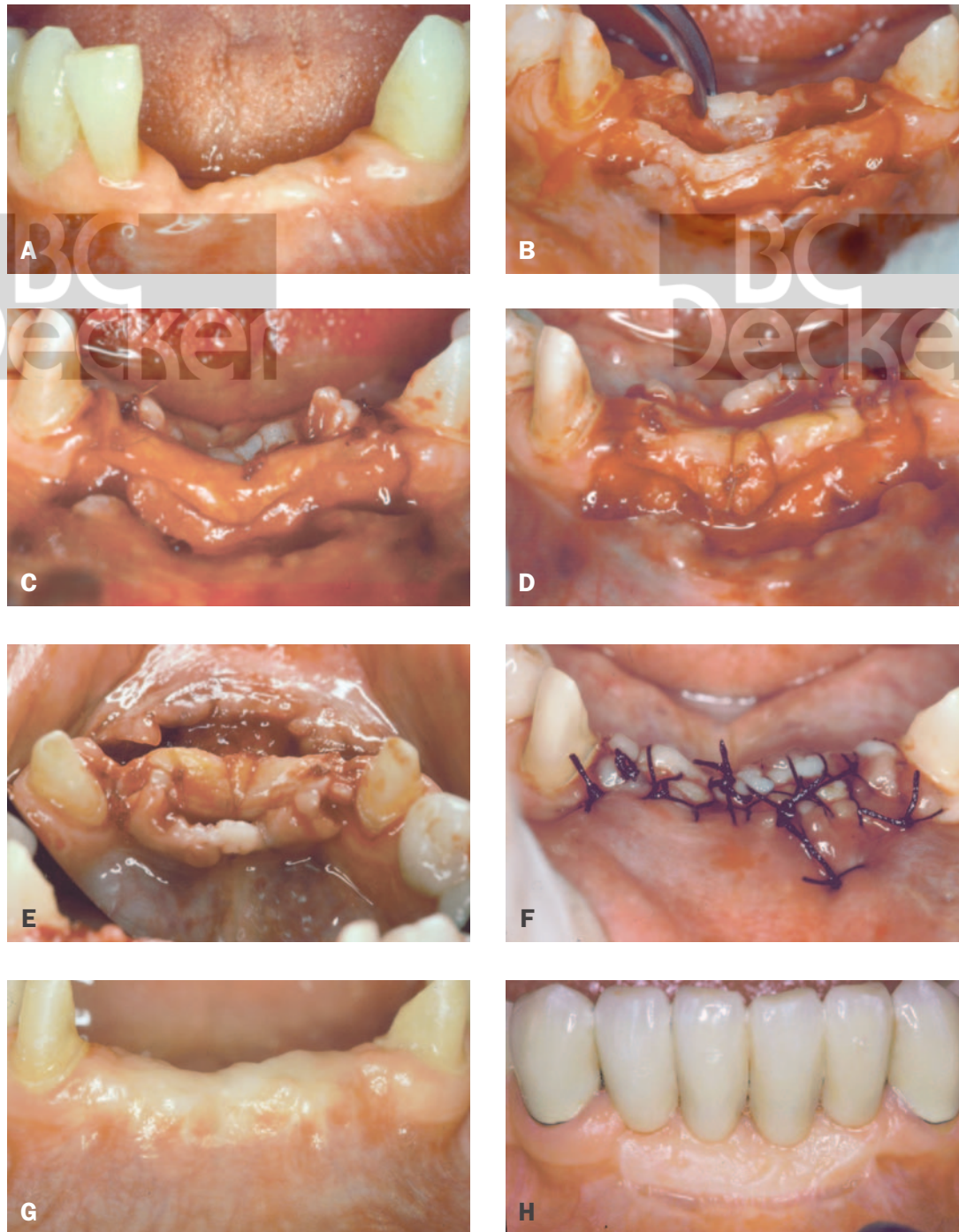


FIGURE 22-16. Class II ridge correction. *A*, Initial view. Note the thin ridge with a severe defect. *B*, Buccolingual partial-thickness flaps. *C*, First connective tissue graft positioned and sutured with a periosteal suture. *D*, Second connective tissue graft onlaid and sutured with a periosteal suture. *E*, Lingual view of the second connective tissue graft positioned. *F*, Primary closure. *G*, Final ridge. Compare with *A*. *H*, Final prosthetic.



FIGURE 22-17. Correction of a Class II ridge defect. A and B, Facial and lateral preoperative views. Note the long modified ridge lap pontics, especially tooth 10. C and D, Collapsed Class III ridge defect, lateral and facial views. E, Occlusal view showing ridge asymmetry. G, pre-operative surgical view after fenectomy. H, First CT graft positioned and stabilized to prevent any movement. I, Second CT graft positioned and stabilized over initial graft. J, Flap coronally positioned with primary closure. K, Three months later with ideal ridge form established. Compare to E. L, Gingivoplasty for development of pontic form and gingival scallop. M, Final temporization with ovate pontics for ridge establishing contours. N and O, Final prosthetic result. Compare to A and B. Note esthetic gingival form with no use of modified ridgelap pontics.

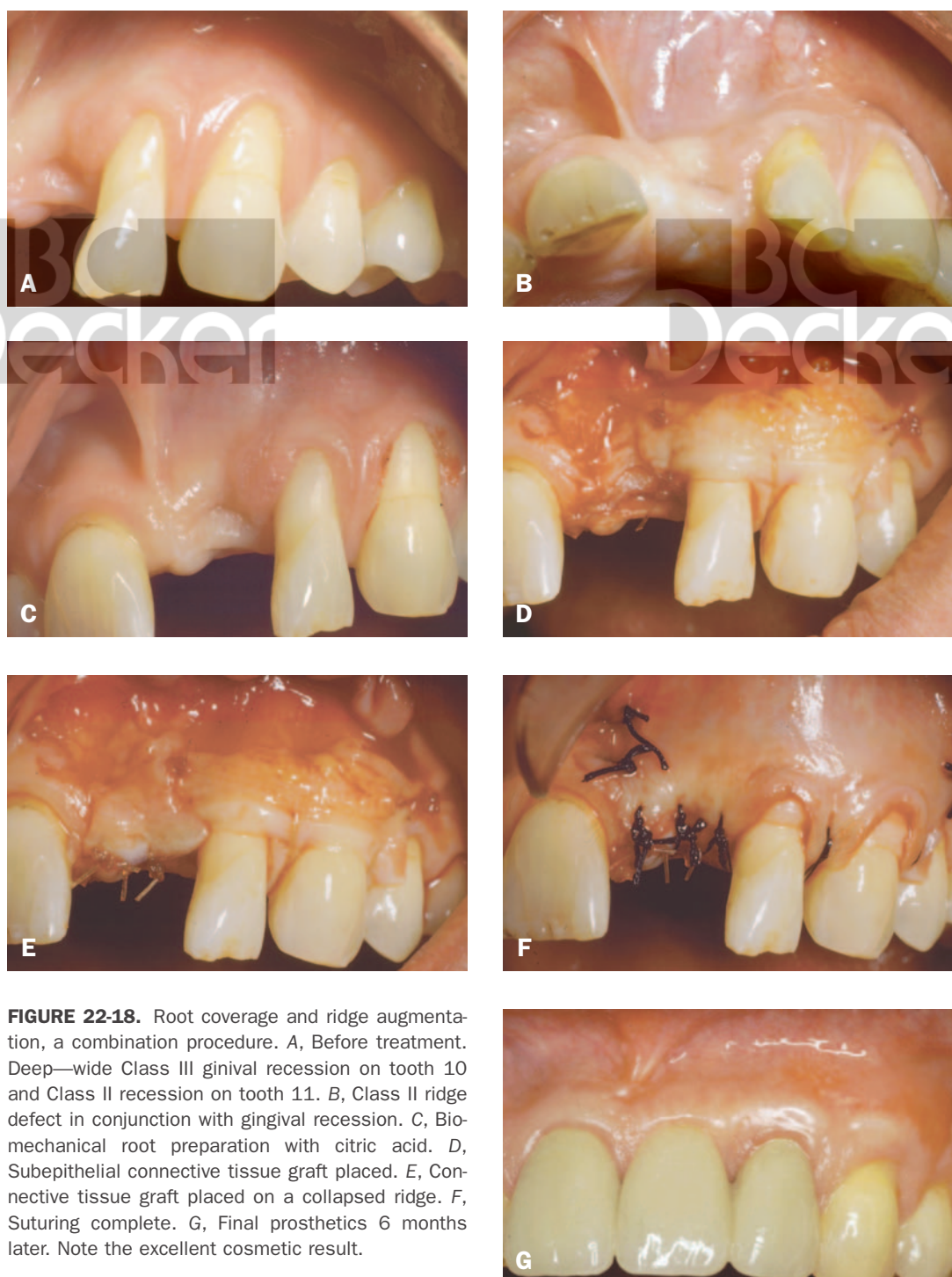
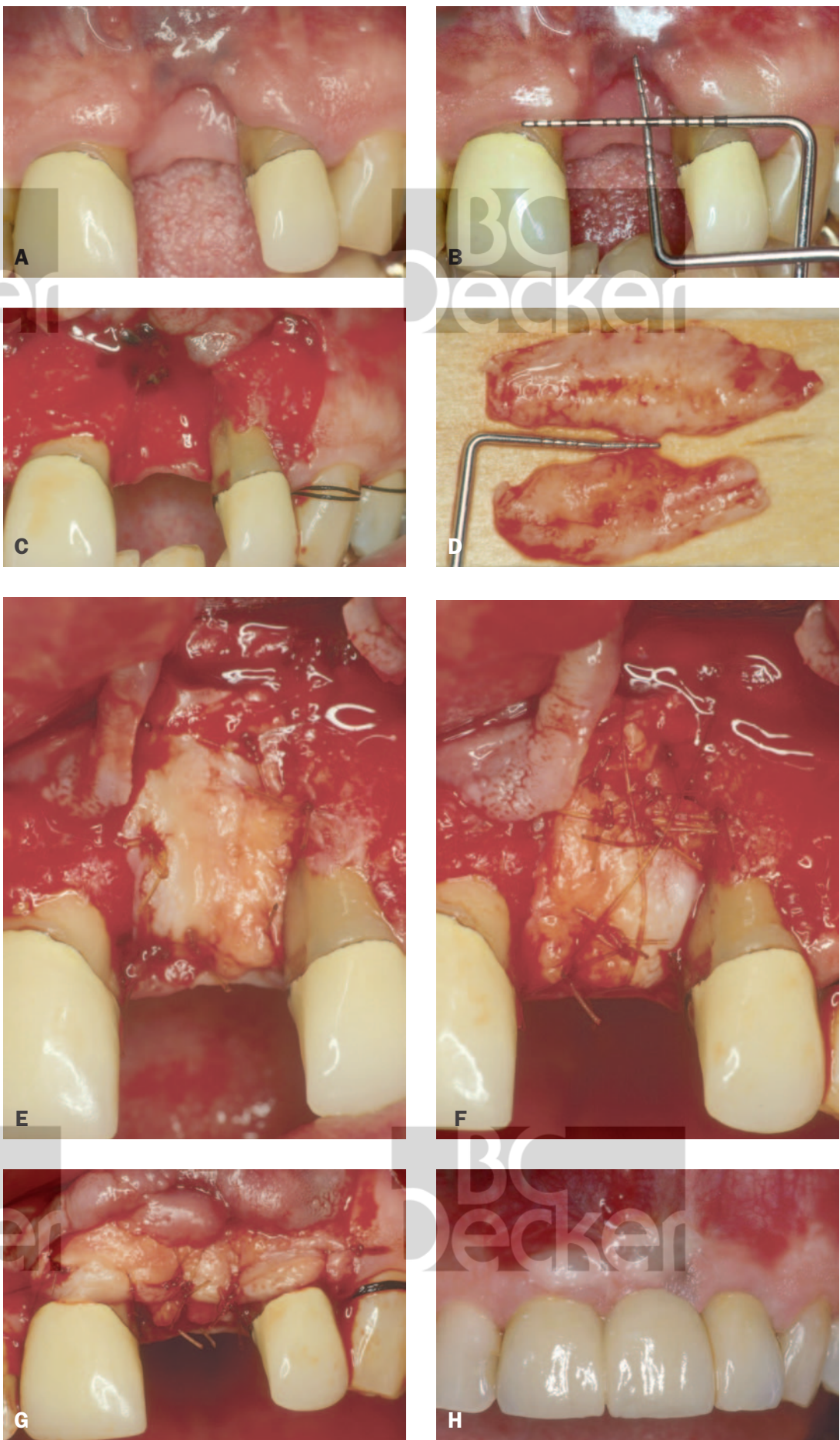


FIGURE 22-18. Root coverage and ridge augmentation, a combination procedure. *A*, Before treatment. Deep—wide Class III gingival recession on tooth 10 and Class II recession on tooth 11. *B*, Class II ridge defect in conjunction with gingival recession. *C*, Bio-mechanical root preparation with citric acid. *D*, Subepithelial connective tissue graft placed. *E*, Connective tissue graft placed on a collapsed ridge. *F*, Suturing complete. *G*, Final prosthetics 6 months later. Note the excellent cosmetic result.

FIGURE 22-19. Root coverage and ridge augmentation: a combination procedure. *A*, Preoperative view. *B*, Probes showing a soft tissue defect, 10 × 5 mm. *C*, Partial-thickness flap reflected. *D*, Multiple large grafts taken. *E*, First connective tissue graft positioned in the defect. *F*, Second connective tissue graft onlaid onto the first graft. *G*, Third connective tissue graft used in root coverage. *H*, Final restoration. Compare with *A*.



Interpositional Onlay Graft

Siebert and Louis (1995, 1996) developed this procedure for treatment of large Class III ridge defects. It was meant to combine the best procedures of the interpositional graft and the onlay graft into one procedure.

1. Increased revascularization of the onlay graft
2. Smaller palatal wound
3. Less morbidity
4. Increased ability to control direction of augmentation
 - a. Apicocoronal
 - b. Buccolingual
5. No alteration in vestibular depth

Procedure

Deepithelialization.

1. With a 15C scalpel blade, the epithelium over the coronal aspect of the ridge is removed.
2. Deepithelialization is carried mesial and distally to the adjacent papilla.

Note: The papillary tissue, if present, is not included in the surgery.

3. Vertical grooves in the ridge are sometimes advocated for increased vascularization of the onlay portion of the graft (Siebert, 1991).

Pouch.

1. With a 15C scalpel blade, a partial-thickness pouch procedure is performed (see Pouch Procedure).
2. Unlike the basic pouch procedure, Siebert and Louis (1995, 1996) advocate the use of a vertical releasing incision at the terminal ends of the deepithelialized ridge.

Note: This will facilitate placement and stabilization of the connective tissue portion of the graft.

3. Measurements are now made to confirm the size requirements for the connective tissue and epithelialized portions of the graft.

Graft.

1. The epithelialized and connective tissue portions of the graft are determined. The graft is generally trapezoidal in shape.

Note: The bicuspid area is the best site from which to obtain the graft. If the palatal vault is not adequate, this procedure cannot be performed.

2. The flap is sutured closed with 4-0 silk.

The clinical pictures are depicted in Figures 22-21 and 22-22.

Interpositional Graft. The interpositional graft (Siebert, 1992) is almost identical to the pouch procedure except that a thick epithelialized connective tissue graft or “wedge” is positioned between the free edge of the pouch and the exposed portion of the ridge. It is used for treatment of Class I ridge defects.

Unlike the true pouch procedure, the epithelial surface of the graft is left exposed and vertical incisions may also be employed.

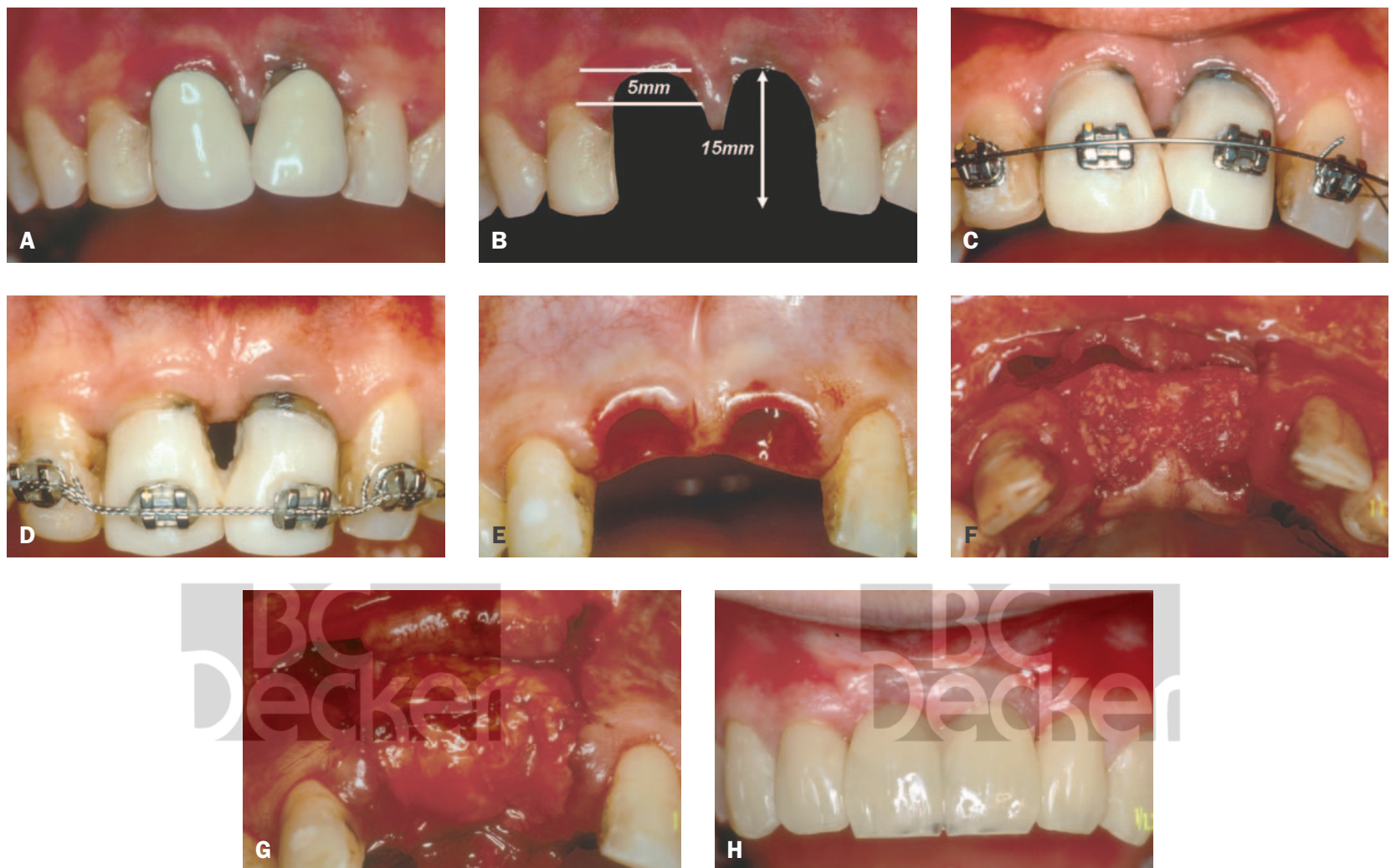


FIGURE 22-20. Ridge augmentation for prosthetic enhancement using a combination of orthodontic extrusion socket preservation and ridge augmentation. A, Before. Teeth #8 and #9 are to be extracted due to advance periodontal disease. B, Diagrammatic view of gingival margin if teeth were extracted immediately resulting in a severe ridge defect. C, Orthodontics begun after initial scaling and roof planning. D, Orthodontic extrusion resulting in significant coronal marginal movement 3 months later. E, Gingival margin at time of tooth extraction. Compare to A and B. F, Socket preservation with DFDBA. G, Connective tissue grafts positioned (buccal and occlusal) for final ridge contours. H, Final result with complete ridge and esthetic restoration. Courtesy of Dr. Scott Kissel, New York, NY.

Graft Stabilization

1.

All suturing is carried out with chromic sutures (4-0 or 5-0) with a P-3 needle.
2.

The connective tissue portion of the graft is stabilized in the pouch first.
3.

The onlay portion is sutured palatally.
4.

The pouch is sutured to flush with the epithelial portion of the graft once the graft has been adequately stabilized.

Note: If a temporary bridge is being worn, it must be reduced so as not to impinge on the graft when it swells.

The clinical procedure is depicted in Figure 22-5.

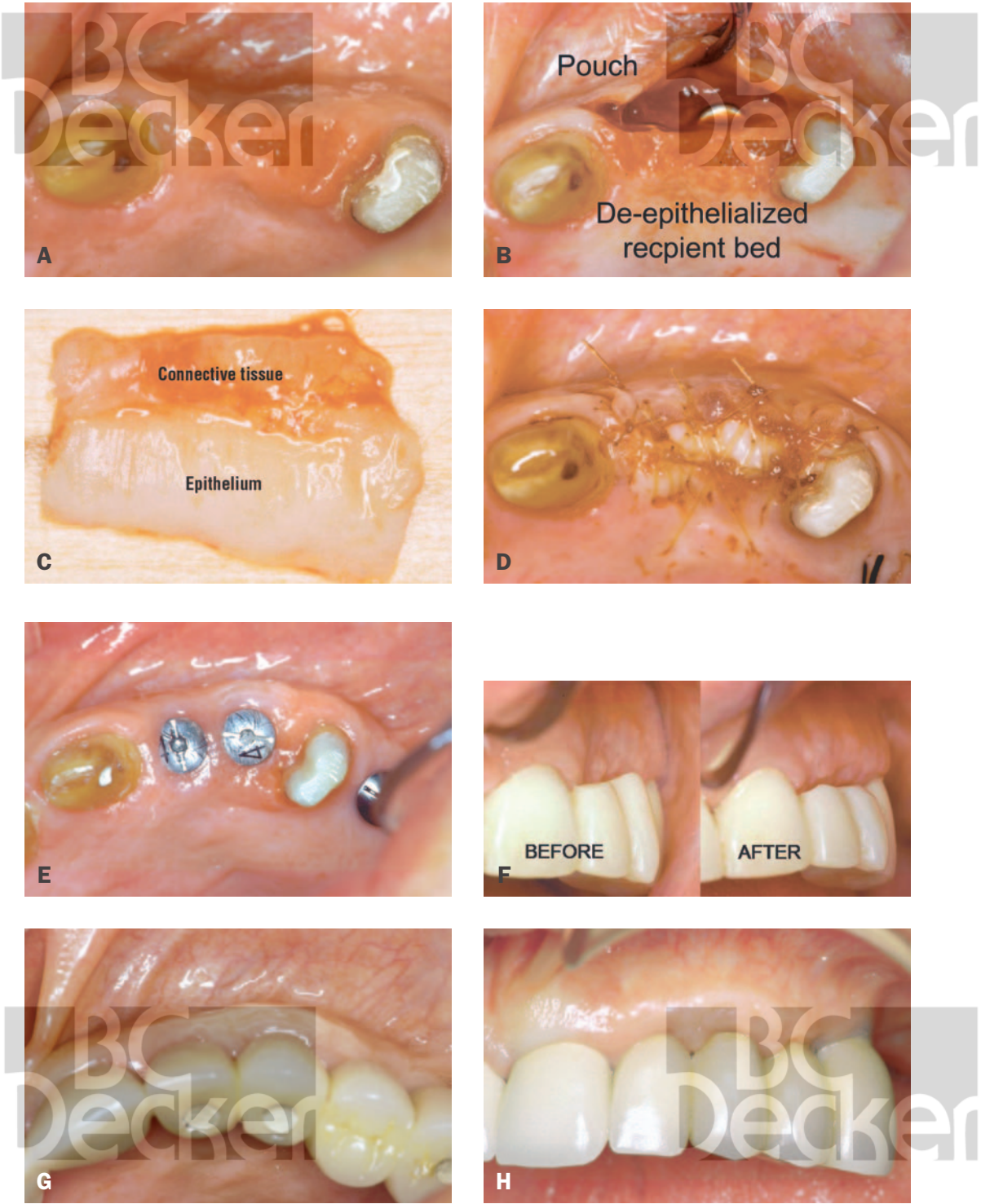


FIGURE 22-21. Interpositional onlay graft. *A*, Preoperative occlusal view showing inadequate buccal width. There is also inadequate vertical height. *B*, Partial-thickness buccal pouch with a deepithelialized edentulous ridge. Vertical slices are sometimes made on the ridge to increase bleeding. *C*, Epithelialized–connective tissue composite graft. *D*, Epithelialized portion of the graft placed onto the ridge and the connective tissue portion placed into the pouch. *E*, Implant exposed with healing caps. Note the increased contour of the ridge. *F*, Before and after showing significant facial and occlusal gain in tissue thickness. *G* and *H*, Final prosthetics with excellent ridge and papillary development.

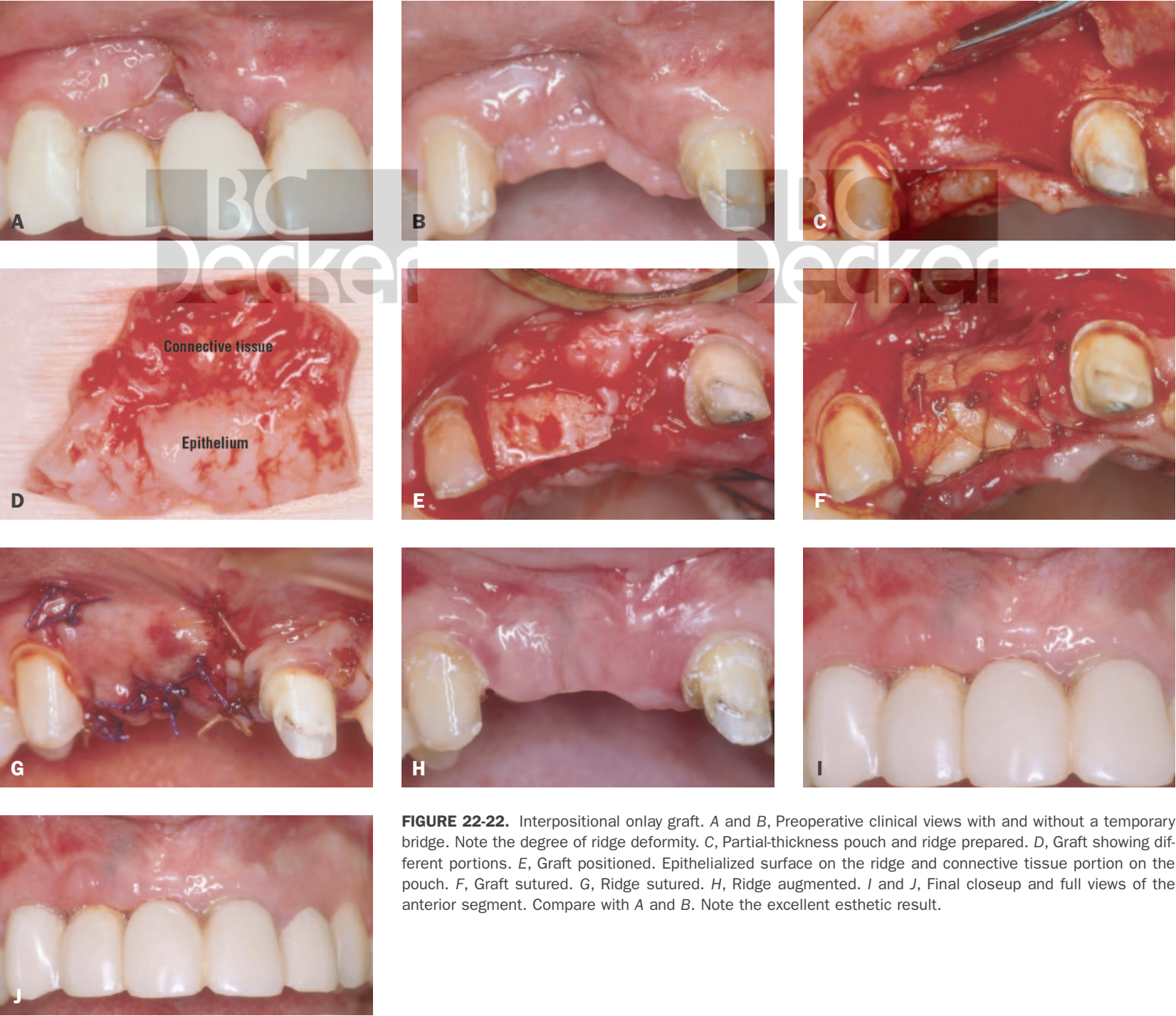


FIGURE 22-22. Interpositional onlay graft. *A* and *B*, Preoperative clinical views with and without a temporary bridge. Note the degree of ridge deformity. *C*, Partial-thickness pouch and ridge prepared. *D*, Graft showing different portions. *E*, Graft positioned. Epithelialized surface on the ridge and connective tissue portion on the pouch. *F*, Graft sutured. *G*, Ridge sutured. *H*, Ridge augmented. *I* and *J*, Final closeup and full views of the anterior segment. Compare with *A* and *B*. Note the excellent esthetic result.



Socket Preservation

Prevention of alveolar bone loss postextraction was first described by Greenstein (1985) and Ashman and Bruins (1985). The term *socket preservation* was first coined by Cohen (1988) for a procedure designed for prosthetic socket maintenance, ridge preservation, and ridge augmentation. It provides for greater control and greater predictability while preventing site collapse and esthetic compromise. Socket preservation at the time of extraction is one of the most significant procedures in the modern periodontal paradigm for maintenance of health, youth, and beauty.

A number of studies have shown that without treatment, significant alterations in most extraction ridge dimensions will occur (Amler and colleagues, 1960; Atwood, 1963; Carlson and colleagues, 1967a, 1967b; Johnson, 1969; Pietrokows, 1969; Abrams 1987; Lekovic and colleagues, 1997; Lekovic and colleagues, 1998; Isella and colleagues, 2003; Schropp and colleagues, 2003). These changes range from an average vertical bone loss of 1.5 to 2 mm to an average loss of 40 to 50% in socket width 6 to 12 months postextraction, with most of the loss occurring during the first 3 months (Schropp and colleagues, 2003). It is important to note that in those patients in whom socket preservation procedures were used, there were few or no changes, and what changes that did occur were significantly less than when no treatment was performed (Lekoic and colleagues, 1997, 1998; Isella and colleagues, 2003).

Maintenance of Gingival Contours

The single most important esthetic goal of socket preservation is maintenance or enhancement of the facial and interproximal gingival contours and height of the interproximal papilla.

General Esthetic Considerations

1. Lip line
2. Position of the tooth in the arch
3. Gingival and underlying osseous form
4. Initial provisional prosthesis
 - a. Fixed
 - b. Removable
5. Final prosthesis for the extraction site
 - a. Pontic
 - b. Implant
6. Amount of bone loss

7. Height of adjacent bone
8. Presence or absence of the buccal plate of bone
9. Maintenance of the existing bridge

Factors Determining Interproximal Tissue Height (Saadoun and LeGall, 1998)

1. The peak of the interproximal bone
2. Contact point height
3. Periodontal biotype (Oschenbein and Ross, 1969; Weisgold, 1977)
4. Distance from the contact point to the interproximal bone (Tarnow and colleagues, 1992, 2003; Cho H-S and colleagues, 2006)
5. Tooth form
6. Interproximal distance between adjacent teeth, adjacent implants, or the adjacent tooth and implant (Tarnow and colleagues, 2000; Gastaldo and colleagues, 2004)

Kois (1994, 1998) and Spear (1999) noted the 1.5 to 2.5 mm distance between the facial (3 mm) and interproximal (4.5–5.5 mm) gingival margins to the crest of bone. Kois (1998) stated: “When a tooth is removed and a confined embrasure no longer exists, the interproximal papilla recedes to the same 3mm level above the bone as it exists facially.” Therefore, the best way to prevent the interproximal scallop from flattening out is to immediately replace the lost tooth with an “anatomic substitute” (pontic) and reestablish the gingival embrasure (Kois, 1998).

Rules

1. If you have a papilla, keep it.
2. If you do not have a papilla, create it.
 - a. Requires bulk of tissue
 - b. Pontic must sit in tissue, not on it

Note: The combination of socket preservation and gingival embrasure maintenance at the time of extraction will preserve the facial and interproximal gingival levels.

Indications

1. Esthetic maintenance and enhancement
2. Ridge and socket preservation and enhancement
3. Improved bone quality
4. Enhanced implant placement
5. Enhanced pontic design

Advantages

1. Simple
2. Effective
3. Minimize postoperative pain
4. Will prevent future need for secondary surgical procedures for ridge augmentation

Presurgical Analysis (Sottosanti, 2003)

To effectively analyze and determine the surgical requirements, the clinician must know

1. The overall treatment plan
2. The type of transitional restoration
 - a. Fixed
 - b. Removable
3. The final prosthetic treatment plan
 - a. Implant
 - Requires a bony architecture for integration; therefore, surgery will be guided bone regeneration (GBR) for the socket and ridge.
 - Preservation
 - Augmentation
 - Height
 - Width
 - Volume

Note: Loss of interproximal bone height may necessitate both GBR and soft tissue augmentation for esthetic implant placement.

- b. Pontic (Figure 23-1)
 - Requires only a soft tissue ridge form conducive for development of an ovate pontic form

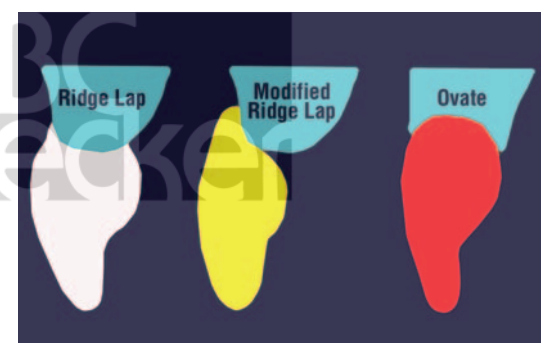


FIGURE 23-1. Three different pontic designs.

4. Any other adjunctive services that may be required
- a. Orthodontics
 - b. Endodontics
 - c. Oral surgery

Socket Preservation Procedures

Basic socket preservation, although similar in all cases, varies with the method of socket closure. As a result, there are a number of different so-called socket preservation procedures:

- 1. Connective tissue graft (Langer and Calan-gar, 1980) (Figures 23-3 to 23-8)
- 2. Socket seal or free gingival graft (Landsberg and Bichacho, 1994) (Figure 23-9)
- 3. Bio-Col or resorbable hemostatic plug technique (Sklar, 1999) (Figure 23-10)

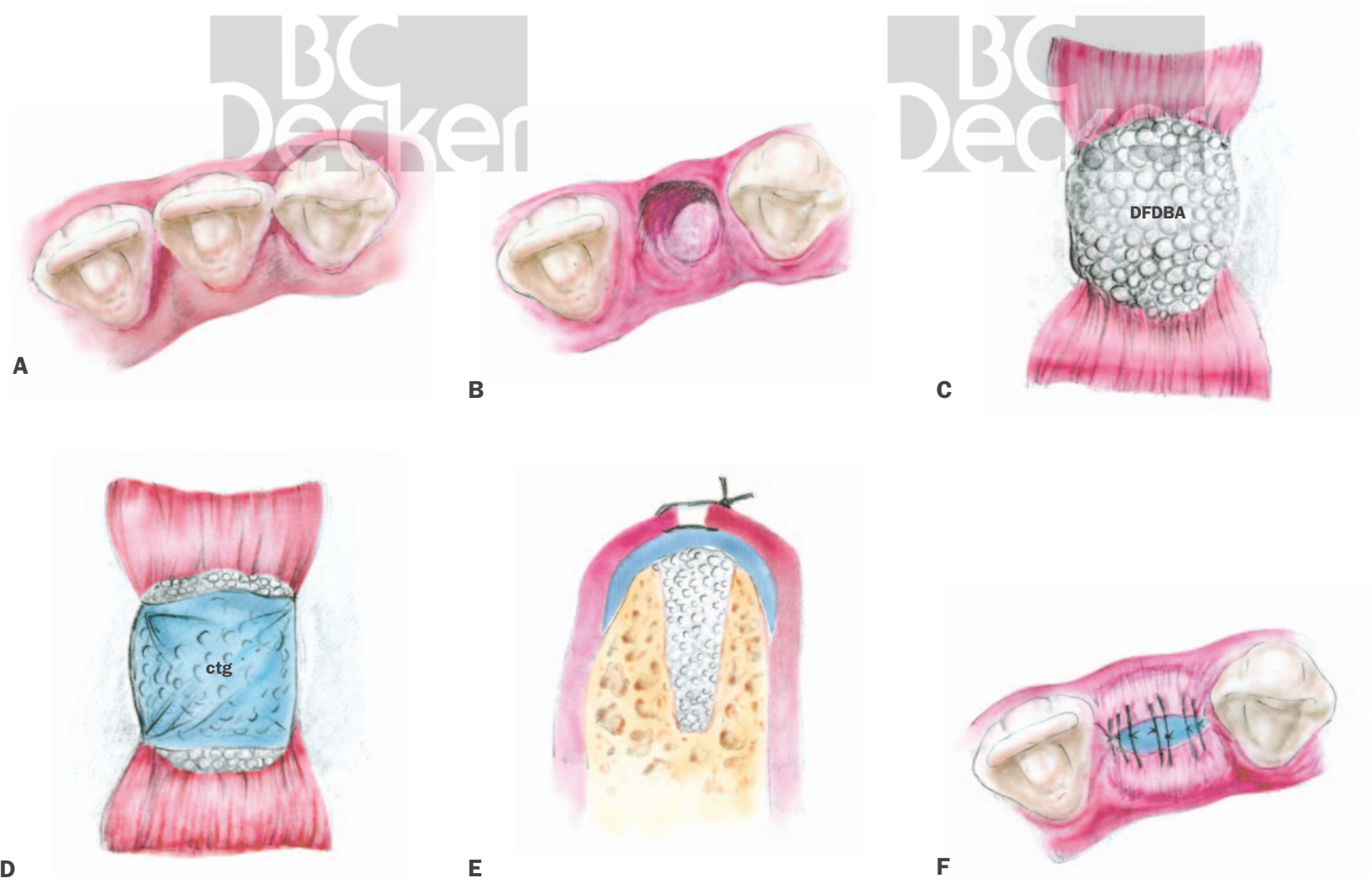


FIGURE 23-2. Socket preservation. A, Before the lateral (middle) tooth is extracted. B, Tooth extracted. C, Socket filled with DFDBA or another implant material. D, Connective tissue graft placed for biologic cover. E, Cross-sectional view of a sutured case. F, Occlusal view of final suturing.

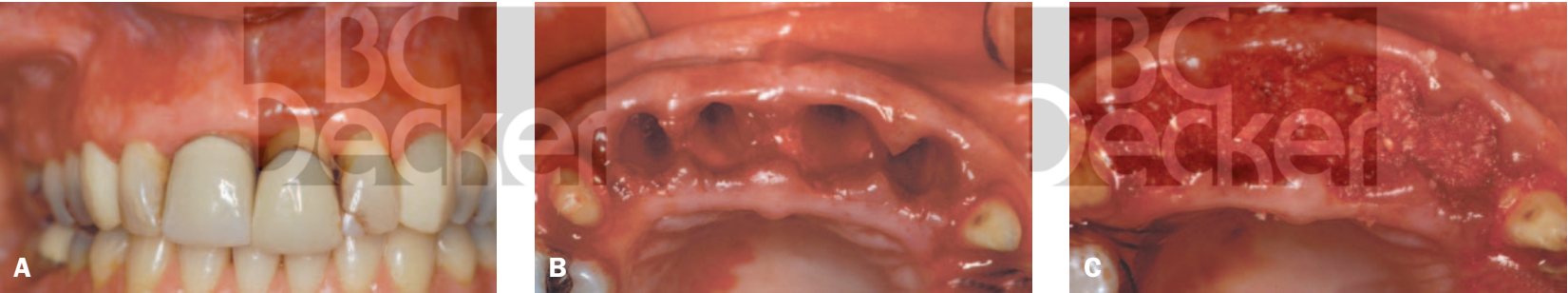


FIGURE 23-3. Socket preservation, ridge augmentation, and prosthetic rehabilitation. A, Preoperative view. Teeth 7 to 10 require extraction. B, Multiple extractions. C, Demineralized freeze-dried bone allograft placed into sockets.



FIGURE 23-3. Continued. D, Connective tissue graft placed over sites. E, Augmented ridge 3 months later. F, a, Ridge gingivoplasty for ovate pontics to be positioned; b, ovate pontics positioned. G, Final papillary form established with a temporary bridge. Note the ideal highly scalloped form achieved. H, Final prosthetics with ideal esthetics. Prosthetics courtesy of Dr. Richard Rossman, Randolph, MA.



FIGURE 23-4. Socket preservation using a connective tissue graft. A, Before. B, Teeth 7 to 9 atraumatically extracted and demineralized freeze-dried bone allograft placed. C, Connective tissue graft placed over sockets. D, Healed ridge being contoured for ovate pontics. E, Final temporization with ovate pontics. F, Final pontic ridge form with interproximal papilla established. G, Ovate pontic form on the final bridge. H, Final bridge. Compare with A and note the excellent gingival scalloped contour. Prosthetics courtesy of Dr William Irving, Needham, MA.

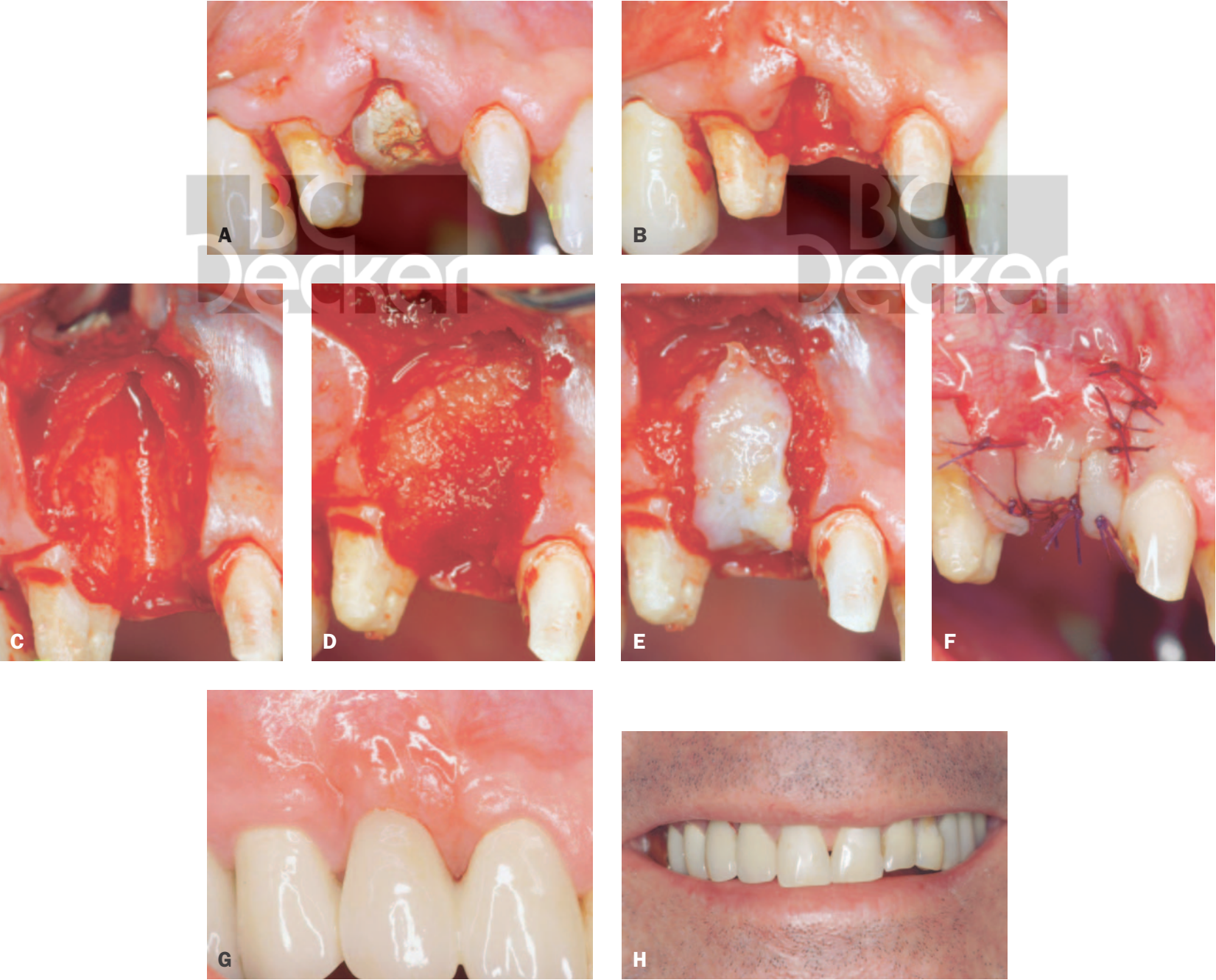


FIGURE 23-5. Socket preservation with a connective tissue graft. *A*, Initial view of tooth 6, which is to be extracted. *B*, Atraumatic tooth removal. *C*, Area flapped showing no buccal plate of bone. *D*, Demineralized freeze-dried bone allograft placed in the socket. *E*, Connective tissue graft placed to retain the graft and add buccal width. *F*, Coronal positioning of the flap to achieve primary closure. *G*, Final prosthetic case. *Note the ideal facial and interproximal contour.* *H*, Final esthetic evaluation. Prosthetics courtesy of Richard Rossman, Randolph, MA.



FIGURE 23-6. Socket preservation for prosthetic maintenance. A, Preoperative view. B, Root removed from under tooth 12. C, Demineralized freeze-dried bone allograft placed. D, Connective tissue graft placed unsutured. E, 4-0 or 5-0 Vicryl sutures placed for 2 weeks. F, Final healing 6 months later. Note the esthetic ridge contour.

4. Guided bone regeneration (Figures 23-11 to 23-15)
 - a. Nonresorbable membrane
 - b. Resorbable membrane
 - Normal restorability (4–6 weeks)
 - Extended restorability (4–6 months)
5. Alloderm or acellular dermal graft (Misch, 1998) (see Alloderm)
6. Prosthetic “pontic” socket plug (Figure 23-15)

- a. Removable (Misch, 1998; Kois and Kan, 2001) (Figure 23-16)
- b. Fixed (Kois, 1998; Spear, 1999; Sklar, 1999) (Figures 23-17 and 23-18)

Procedure

Atraumatic removal of the root is the most important and difficult part of the procedure. It must be carried out slowly and carefully.



FIGURE 23-7. Basic procedure with a connective tissue graft. A, Initial view. B, After temporization. C, Temporary bridge removed. Tooth to be extracted reduced to gingival height. D, Atraumatic tooth removal. E, Demineralized freeze-dried bone allograft placed. F, Connective tissue graft positioned and sutured over the socket. G, Final ridge contour. H, Final prosthetics completed. Note the excellent esthetic result. Prosthetics courtesy of Dr. David Edward, Bridgewater, MA.

Goal

The goal of this procedure is preservation of the buccal and lingual plates of bone.

1. Instrumentation
 - a. No. 15c scalpel blade
 - b. Periotomes
 - c. Small elevators
 - d. High-speed drill and burs
 - Neumeyer bur
 - 701L
 - 2A. A 360° sulcular incision is performed with a 15c scalpel blade about the tooth or root down to the osseous crest (supracrestal fiberotomy). This will sever all remaining fibers and prevent inadvertent tearing of the flap.
 - 2B. The blade is now carefully worked 2 to 3 mm below the osseous crest.
 3. A flat “periotome” is the first instrument to be used.
 4. The top of the periotome is inserted interproximally or at the interproximal line angles until an adequate purchase is established.
 5. The root is luxated in a mesiodistal direction while alternating the sides of the tooth. This will slowly widen the socket.
- Note:** Elevation in a buccal direction is to be avoided because fracture of the labial plate of bone may occur.
6. Once movement is established, a small elevator with a pointed curved tip is introduced to further widen the socket and elevate the root. With patience, the tooth will be elevated out of the socket.

Note: Horowitz (2006) recommended that molars be sectioned for root separation prior to extraction.

7. If movement cannot be established or fracture of the buccal plate appears to be imminent, then the root should be sectioned. This is easily accomplished by using the Neumeyer bur to hollow out the center of the root and the 701L bur to help section it in a buccopalatal direction. The split roots are then removed individually.
8. Once the root is removed, the socket is carefully débrided of granulation tissue and residual periodontal connective tissue fibers. Excessive pressure on the labial plate is always to be avoided (see Figure 23-2B).

Adding CaSO_4 to any graft will increase the volume of new bone and decrease the replacement time of any graft material (Sottosanti, 2003; Guarnieri, 2004).

9. After curettage and débridement of the socket and sulcus, the walls of the socket are now checked for dehiscences and/or fenestrations. This is accomplished visually by drying the socket with a slightly moistened woven gauze

- and tactilely with a small curved instrument. The instrument is gently moved up and down the walls, checking for any openings.
10. If the buccal plate of bone is not intact, a resorbable membrane is positioned over the facial defect with a 3 to 4 mm extension onto sound bone. This is accomplished using a circum-elevation technique with a small periosteal elevator. Elevation is begun at the interproximal line angles, extended apically and then facially. Undermining the flap laterally first will reduce unnecessary and potentially damaging pressure on the facial bone.
 11. Once the buccal plate has been evaluated and the need for a membrane is determined, the socket is checked for bleeding. If the socket lacks adequate vascularity, a 1/2 round bur is used to perforate or decorticate the bony walls (except the labial wall) to produce multiple bleeding points.
 12. The socket is now filled with a graft material to the osseous crest.

Note: If an implant is being placed, a suitable graft material (demineralized freeze-dried bone allograft/freezing-dried bone allograft or Bio-Oss mixed with CaSO₄ graft expander) is recommended (4:1 ratio) (see Figure 23-2C).

13. The socket is now covered with suitable material (CollaPlug), a membrane (resorbable or

nonresorbable connective tissue graft), or an acellular dermal material graft that will maintain the graft in position and aid in GBR (see Figure 23-2D).

Note: If implants are to be placed and primary coverage is not possible, a nonresorbable expanded polytetrafluoroethylene membrane (e-PTFE) with or without titanium reinforcement is recommended.

14. The flaps are sutured to secure implant and bondage (see Figure 23-2, E and F)
15. If a fixed or removable appliance has been fabricated, the ovate pontic's form is extended 1.5 mm within the sulcus so that it is within 0.5 mm of the osseous crest on all surfaces.
16. After 4 weeks, the pontic is reduced to 1 mm below the free gingival margin.

Table 23-1 Predictable Results	
Critical Feature	Benefit
Thick flat biotype	Less tissue change
Large papilla healing	Better blood supply for wound
Smaller tooth sockets	Less bone fill required
Flat emergence profile	Reduced pressure on soft tissue
Natural embrasures	Supports soft tissue
Delayed final restoration	Allows for soft tissue maturation

Table 23-2 Keys to Success	
Diagnosis and treatment planning (interproximal bone height, tissue thickness, biotype, smile line, patient expectations)	
Presurgical restorative preparation	
Low-trauma surgical procedures	
Grafting of the socket to reduce postextraction bone loss	
Provisional restoration that supports the gingival complex and papilla	
Frequent postoperative follow-up	
Well-designed and finished final prosthesis	
Good oral hygiene and preventive maintenance	
Adapted from Melnick and Camargo (2004).	

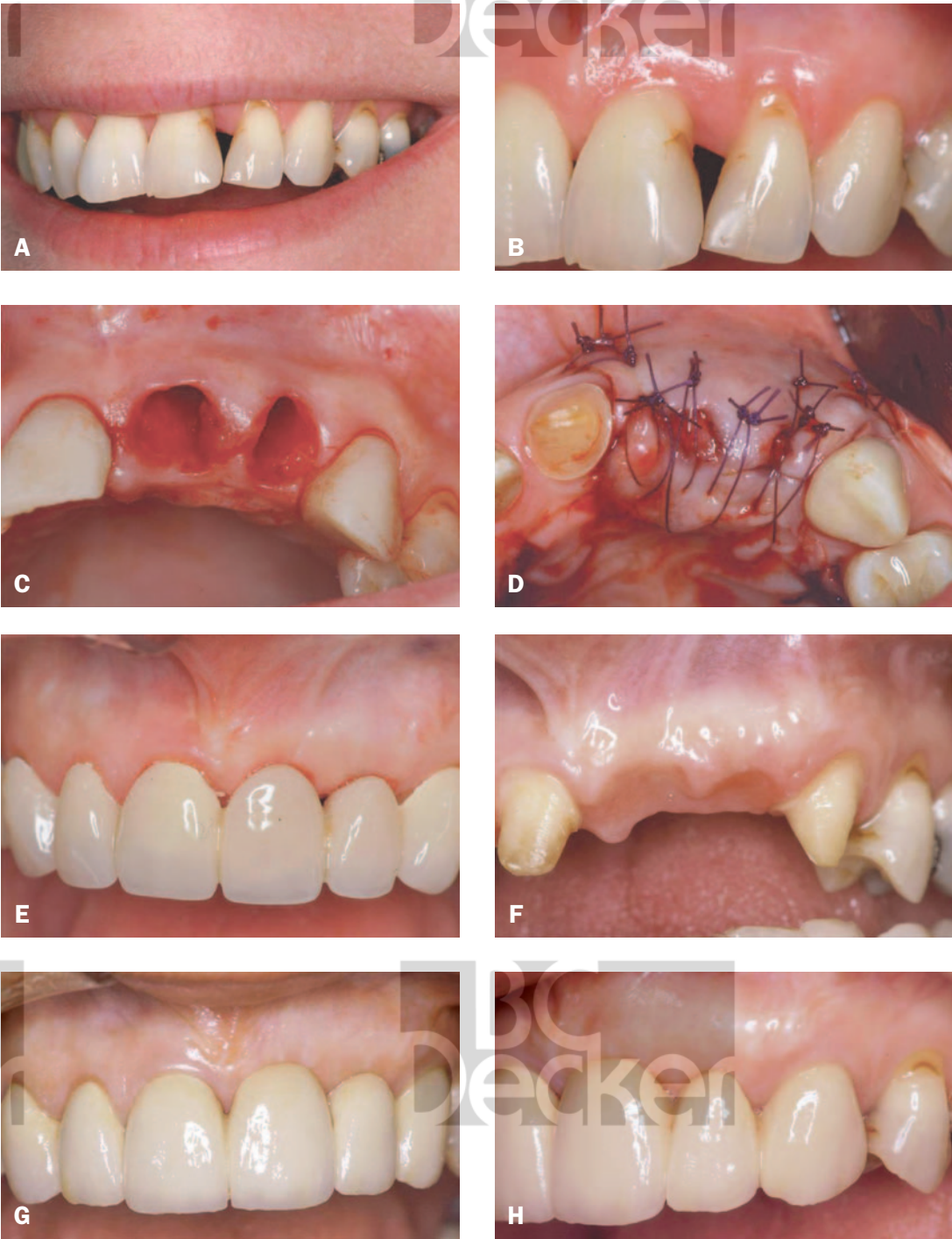


FIGURE 23-8. Socket preservaion, ridge augmentation, and prosthetic rehabilitation. A, Initial smile view showing high smile with unsightly space. B, Close-up view of tissue recession between teeth 9-10. C, Atraumatic extraction of teeth 9/10. D, Socket preservation with DFDBA and CTG. E, Final temporaries in position to develop ridge form. F, Final ridge form and papilla developed. G and H, Final prosthetic case. Note almost ideal gingival and papillary form has been achieved. (Prosthetics by Dr. Michael Katz, Westport, MA)



FIGURE 23-9. Socket seal/free gingival graft. A, Preoperative view. Tooth 8 to be extracted. B, Atraumatic tooth removal. C, Free gingival graft taken. D, Free gingival graft placed over the grafted socket. E, Healed ridge. F, Ridge gingivoplasty. G, Temporization. H, Final prosthesis.



FIGURE 23-10. Socket preservation for future implant placement. Bio-Cal technique. *A* and *B*, Preoperative view. Teeth 7 and 9 require extraction. Note the unsightly smile and elongated lateral incisor. *C*, Atraumatic extraction. *D*, Grafts placed (tooth 7, demineralized freeze-dried bone allograft; tooth 9, Bio-Oss). *E*, Collaplug material positioned and sutured. Horizontal mattress and individual sutures are used to stabilize the material. *F*, Cyanoacrylate applied to help stabilize the graft. *G* and *H*, Final prosthesis. Note the esthetic gingival line of the lateral incisor and the excellent esthetic result. Compare with *A* and *B*.

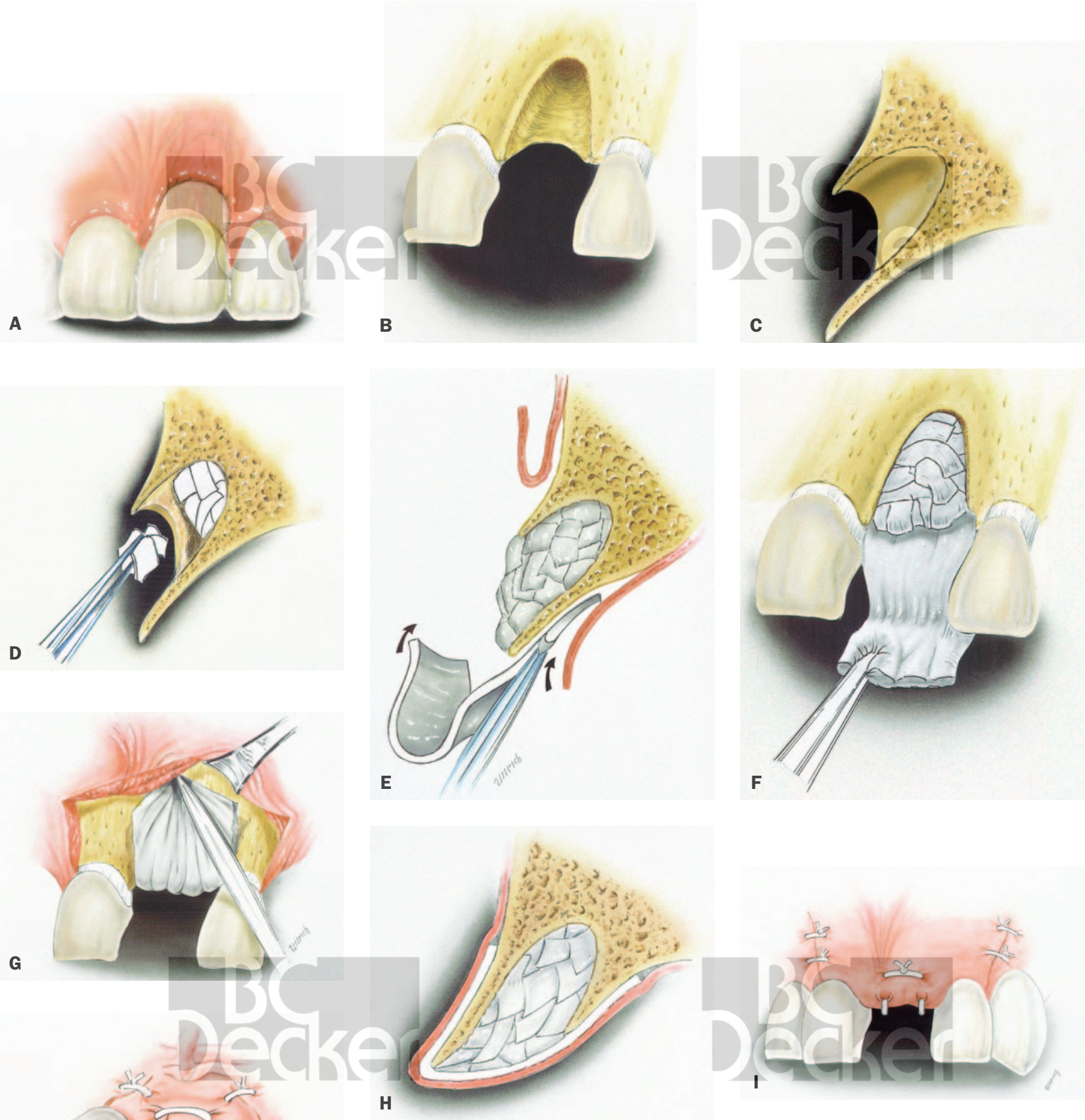


FIGURE 23-11. Diagrammatic view of socket preservation for future implant placement. A, Initial view of a tooth with significant facial recession. B and C, Facial and lateral views showing significant bone loss after tooth removal. D, Graft material placed into the socket. E, Graft material is used to fill the socket and contour ridge. A membrane is now employed. *Note: A titanium-reinforced membrane (e-PTFE) is necessary if there is inadequate membrane support from the osseous walls.* The membrane is first inserted palatally. F, The membrane is brought facially. G, The membrane is inserted buccally. H, Final lateral view with the graft and membrane positioned. I and J, Final suturing, facial and palatal views. *Note the combination facial and vertical mattress suture for closure. If primary closure is not anticipated, then a nonresorbable membrane (Gore-TEX) is recommended.*

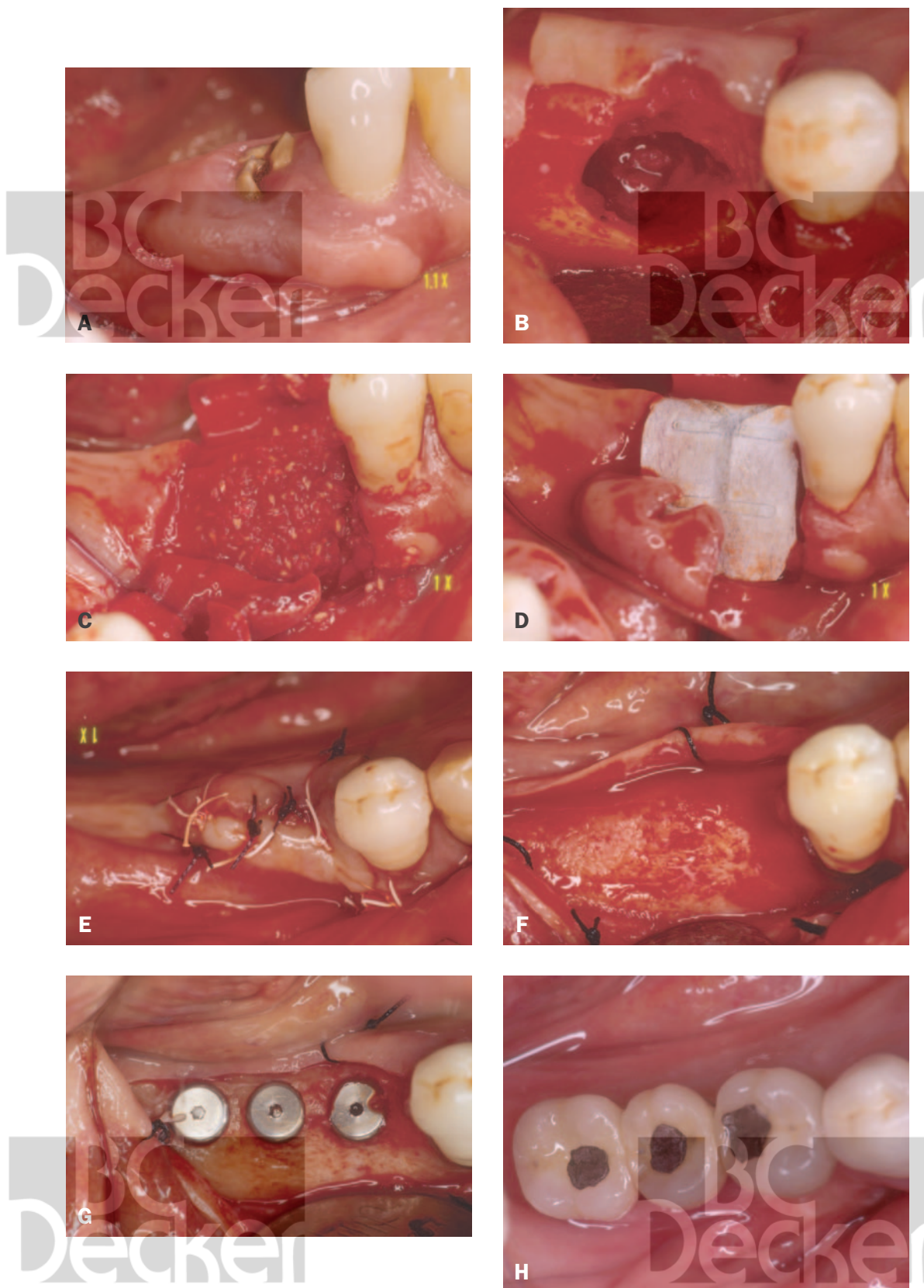


FIGURE 23-12. Socket/ridge augmentation for future implant placement. *A*, Preoperative clinical view. *B*, Tooth extracted, leaving a large ridge defect. *C*, Demineralized freeze-dried bone allograft placed into the socket. *D*, Titanium-reinforced membrane (Gore-Tex) positioned. *E*, Primary closure achieved. *F*, Reentry at the time of implant placement; 100% bone regeneration. *G*, Implants placed in the ideal position. *H*, Final prosthetics completed. Prosthetics courtesy of Dr William Irving, Needham, MA,



FIGURE 23-13. Socket preservation, implant placement, and guided tissue regeneration with a nonresorbable membrane. *A*, Before. Tooth 9; external resorption requiring extraction. *B*, Tooth extracted and implant placed. Note that the flap reflection did not involve the incisal papilla. *C*, A nonresorbable membrane (e-PTFE) placed and suturing completed. Intrapapillary sutures are used to coronally position the flap and papilla on the mesial aspect of tooth 10. *D*, Membrane removed 6 months later. *E*, Final ridge healing. Note excellent tissue height with minimal loss of papillary height. *F*, Implant exposed and custom abutment placed. *G*, Immediate temporization for papillary support. *H*, Final result. Note the excellent esthetic result.

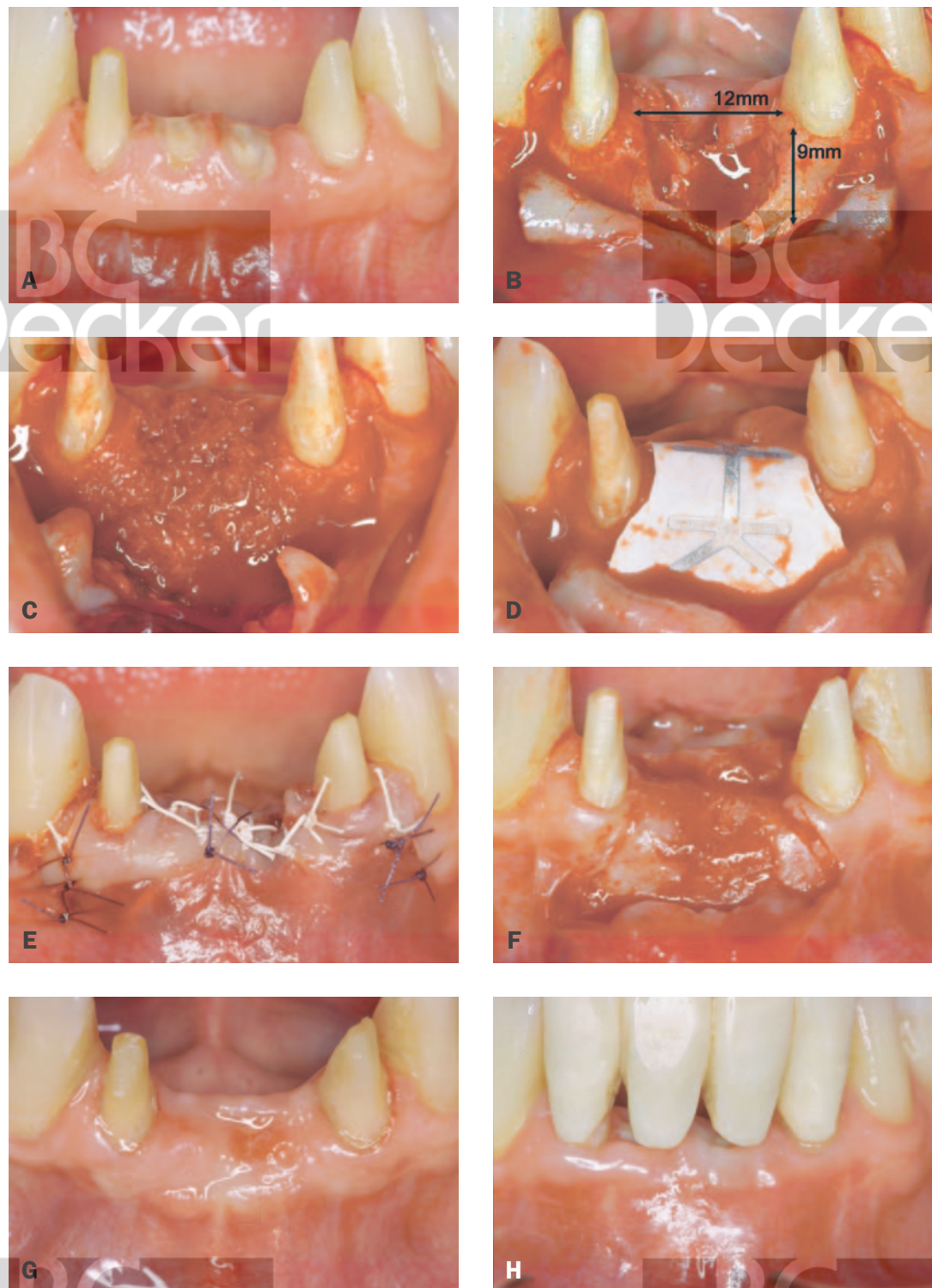


FIGURE 23-14. Socket preservation and guided tissue regeneration. *A*, Initial view. Teeth 24 and 25 to be extracted. *B*, Extraction of teeth 24 and 25 and exposure and clean-out of the infected area show complete loss of buccal and lingual bony plates. Note that the area is too large for tissue augmentation. *C*, Irradiated fresh frozen bone (Rocky Mountain Tissue Bank). *D*, Titanium-reinforced Gore-Tex. *E*, Primary closure achieved. *F*, Gore-Tex removed 2 months postoperatively. *G*, Final healed ridge. *H*, Temporary bridge inserted. Note complete ridge restoration.

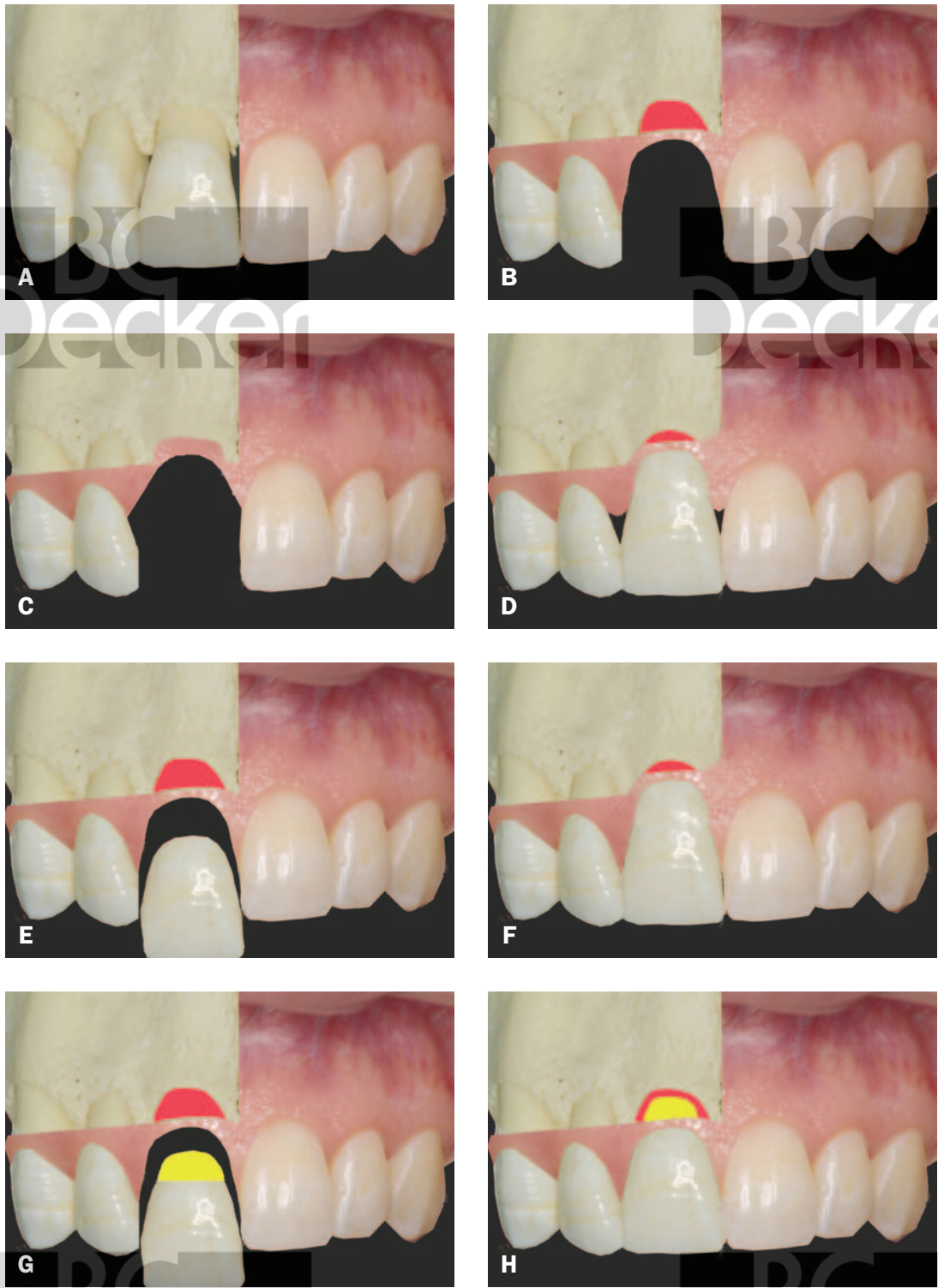


FIGURE 23-15. Diagrammatic view of the basic prosthetic procedure. *A*, Initial view. *B*, Tooth extracted atraumatically. *C*, If the tooth is not replaced, there is loss of interproximal and facial tissue height. *D*, Delayed tooth replacement results in papillary and facial tissue loss, resulting in a longer tooth with black interproximal spaces. *E*, Immediate tooth replacement for interproximal support only. *F*, Note maintenance of interproximal height but loss of facial tissue. *G*, Immediate replacement for both interproximal tissue support and subgingival (yellow area) support. *H*, Ideal esthetics achieved with no loss of interproximal or facial tissue height.



FIGURE 23-16. Socket preservation with immediate implant placement. *A*, Initial view. Teeth 8 and 9 require extraction. *B*, Teeth 8 and 9. Note external root resorption. *C*, Implants positioned. *D*, Closure with demineralized freeze-dried bone allograft material. *E*, Partial denture for lateral and facial gingival support and maintenance of gingival contours. *F*, Healed ridge. Note preservation of facial and interproximal tissues. *G*, Implants exposed. *H*, Final crowns. Note the excellent esthetic result. Courtesy of S. Silverman, Massachusetts.



FIGURE 23-17. Prosthetic socket preservation. *A*, Preoperative view. *B*, Temporary bridge removed. Tooth 8 requires extracting. *C*, View showing augmented pontic to provide subgingival support. *D*, Temporary bridge inserted immediately after extraction. *E*, Healed pontic area. Note the perfect facial and interproximal form. *F*, Final for facial and subgingival support (3–4 mm) crowns. Note maximum maintenance of the papilla. *G* and *G'*, Pre- and post-treatment lateral views showing significant esthetic enhancement.



FIGURE 23-18. Prosthetic socket preservation, basic procedure. *A*, Initial view of a temporary bridge. *B*, Temporary bridge removed showing the tooth reduced to the gingival level. *C* and *D*, Atraumatic tooth removal. *E*, Demineralized freeze-dried bone allograft placed into the socket at the level of the bony crest. *F*, Facial view of a modified temporary bridge. *Dotted line* indicates the subgingival portion (3–4 mm). *G*, Occlusal view showing the ovate pontic. *H*, Temporary bridge being reinserted. *Dotted line* is subgingival. *I*, Temporary bridge completely seated. *J*, Note the ideal facial scallop and retention of interproximal tissue. *K*, Note the ovate pontic form of the ridge. *L*, Final case. Note the ideal gingival contours, making pontic recognition impossible. Prosthetics courtesy of Dr. David Edward, Bridgewater, MA.



Papillary Reconstruction

Papillary reconstruction is unpredictable at best, with minimal results. Most reports are in the form of individual case presentations (Takei, 1996; Azzi and colleagues, 1999, 2001), with only Neurcovsky (2001) presenting a case series with consistent improvement.

All procedures are a modification of the Takei (1996) procedure and involve sulcular releasing incisions, coronal flap movement, and a connective tissue graft being placed interproximally. The surgical procedure presented here was published by Azzi and colleagues (Azzi modification) (1999), with slight modifications.

Procedure

1. The exposed roots are scaled and root planed for detoxification and, if necessary, flattened.
2. Biomechanical root surface preparation using tetracycline hydrochloride, citric acid (CA), or ethylenediaminetetraacetic acid (EDTA) is performed.
3. Intrasulcular incisions (360°) are made down to bone (15C scalpel blade).
4. The sulcular incisions are performed on the teeth approximating the tissue defect and extended to the next interproximal areas and teeth.
5. The intrasulcular incisions are made 360° about the teeth.

Note: Extreme care must be exercised interproximally to avoid damaging or traumatizing the interproximal tissue.

6. A horizontal incision is begun 3 to 5 mm beyond the mucogingival junction and extended laterally to just beyond the adjacent nonaffected interproximal areas.

Note: The combination of lateral horizontal extension and adjacent interproximal release will facilitate coronal flap movement.

7. A second horizontal fenestrating incision is made down to bone at the terminal end of the apical incision.
8. A full-thickness flap is now raised in an apicocoronal direction with a small periosteal elevator.
9. A small curet is now used intrasulcularly for final interproximal flap release.

10. An Orban knife is sometimes used to facilitate interproximal release of the crestal fibers.

Note: Care must be used to prevent papillary damage or flap perforation.

11. A thick connective tissue graft is obtained from the tuberosity as a distal wedge or palate if thick enough.
12. The connective tissue graft is contoured and positioned and stabilized with a 3-0 or 4-0 chromic suture.

Note: The suture is introduced from the palate side to the interproximal area, through the graft, and back out to the palate and tied. A large enough needle is required to ensure passage into the interproximal area.

13. The flap is now replaced over the graft and coronally positioned and stabilized using a horizontal mattress suture (4-0 or 5-0, P-3, Vicryl) buccally and palatally. The suture is passed over the contact area, permitting coronal stabilization of the tissue.
14. The flap is sutured apically (4-0, 5-0 chromic sutures) to the apical mucosal tissue.

Note: If there is too much tension, the mucosal flap should be released with a periosteal releasing incision.

The clinical procedure is depicted in Figures 24-1 to 24-3)

Pediculated Connective Tissue Graft

The pediculated connective tissue graft is a vascularized subepithelial connective tissue graft designed for esthetic ridge augmentation before, during, or after implant placement. It will help prevent premature membrane exposure and provide sufficient additional vascularized tissue for vertical and buccal ridge augmentation. This procedure involves the passive rotation of an interpositional-periosteal retained connective tissue flap (Sclar, 2003) over the edentulous area onto the buccal surface.

Advantages (Sclar, 2003)

1. Maintains an intact vascular supply
2. Allows large volumes of soft tissue augmentation

3. Excellent esthetic results
4. Minimum postsurgical shrinkage
5. Primary wound closure
6. Reduced morbidity
7. Enhanced bone graft maturation
8. Predictable implant site development

Requirements

1. Minimum pedicle width of 10 mm
2. Minimum buccal extension of 4 mm beyond ridge crest
3. Adequate palatal vertical height
4. Adequate palatal thickness ($\geq 4-5$ mm)

Procedure

Recipient Site

1. A partial- or split-thickness labial pouch is created using a 15C scalpel blade.
2. The incisions are begun on the palatal aspect of the ridge and extended buccally.

Note: In cases of simultaneous implant placement, a full-thickness flap is employed over the crest of the ridge. If additional bone implants (with or without membranes) are required, a full-thickness labial pouch or flap is created.

3. If greater access is required, vertical incisions can be employed. Placement of the vertical incisions will be governed by the esthetic requirements. The flap incisions should avoid involvement of the interproximal papilla.

Donor Site.

Note: This procedure is similar to that for the subepithelial connective tissue graft.

1. The initial incision is begun 2 to 3 mm below and parallel to the free gingival margin on the palate. It is generally started distal to the second bicuspid, where the thicker palatal tissue begins and is extended forward.

Note: If the palatal thickness is adequate and greater extension is required, the initial incisions can be started in the molar areas.

2. A full-thickness perpendicular horizontal incision is made with a 15C scalpel blade down to the bone.
3. The horizontal full-thickness incision is begun at the distal end and brought anteriorly initially to the cuspid area.

4. A vertical split-thickness thinning incision is now begun with a new 15C blade distally and is carried forward to the mesial extent of the edentulous area. *The most apical extent of the thinning incision must go high enough palatally to ensure adequate pedicle width.* Small vertical incisions may be made in the primary flap if greater access is required.

Note: Overthinning will result in necrosis of the primary flap. A primary flap that is too thick will diminish the thickness of the connective tissue graft.

5. A vertical incision is now made on the distal end of the connective tissue graft as far apically as possible.
6. A horizontal apical periosteal releasing incision is begun distally and continued to the mesial aspect of the ridge, where it is undermined. *A minimal width of 8 to 10 mm is recommended for the connective tissue graft.*
7. A Prichard elevator is carefully employed anteriorly and posteriorly to raise a full-thickness connective tissue graft.
8. Once undermined, a tissue forceps is used to hold, stabilize, and stretch the graft while the most apical extent of the pedicle is freed by sharp dissection.
9. Anteropalatally, the base of the pedicle is undermined and the pedicle is checked for freedom of movement and placement. This increases graft elasticity for passive rotation, which may reduce the need for additional incisions. Care must be exercised about the incisal canal and its vessels (Sclar, 2004).
10. Rotation of the pedicle is again checked. If additional release is required, *it should be made at the rotational or pivot point.*

Note: Care must be exercised not to compromise flap vascularity.

11. The pedicle graft is now rotated and positioned over the edentulous area and onto the buccal surface.
12. The buccal flap is checked for freedom of movement. If necessary, an apical releasing incision is performed to reduce tension and facilitate primary closure.

Note: This is not necessary if a pouch procedure was used.

13. Suturing
 - a. Pouch procedure. If a pouch was created buccally, the connective tissue graft is now positioned in the pouch using a horizontal mattress suture through the base of the pouch (see Pouch Procedure in Ch. 22, "Ridge Augmentation") to draw and stabilize the graft apically. Suturing is completed using buccal mattress sutures.

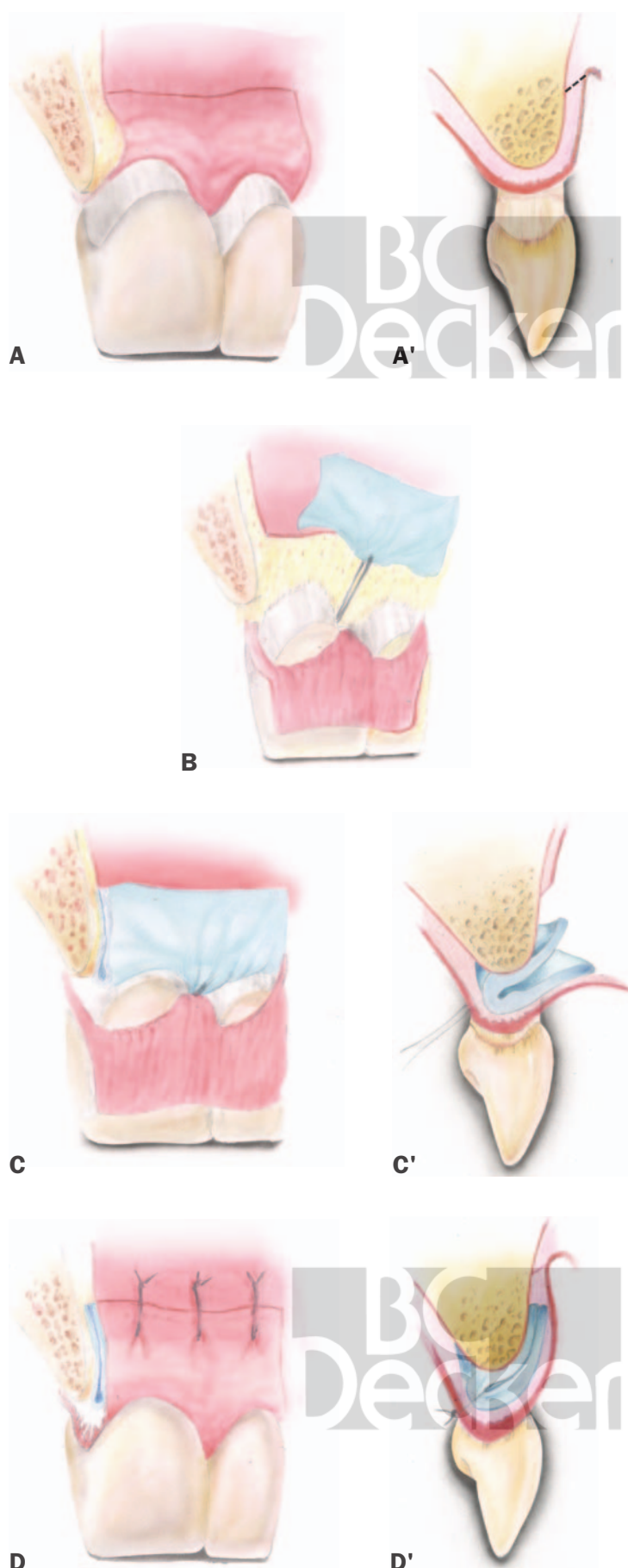


FIGURE 24-1. A and A', Facial and lateral views with incision outlined. B, GMFT being pulled for placement with palatal suture. C and C', Facial and lateral views of graft stabilized with palatal sutures. D and D', Facial and lateral views of flap sutured.

b. Buccal flap. If a full-thickness flap with vertical incisions was employed, the pedicle should be carefully stabilized apically to the periosteum because lateral suturing may not be possible. Horizontal mattress

sutures are used buccally after the primary buccal flap is positioned and stabilized. c. Palatally. The primary palatal flap is closed with suspensory horizontal mattress sutures about the teeth.

Note: If the potential space below the primary flap is too great, then a hemostatic agent (CollaCote, CollaTape, CollaPlug [Integra Lifesciences Corp. Plainsboro, NJ]) may be placed below the flaps prior to suturing.



FIGURE 24-2. Papillary reconstruction and implant coverage (Azzi modification) using the subepithelial connective tissue graft. *A*, Before, with unsightly exposure of the implant. *B* to *D*, Initial impression and diagnostic wax crown fabricated to check the implant position and see if an esthetic result was achievable. *E*, At the time of surgery. *F*, Apical mucosal incision to permit freedom of the coronal flap. *G*, Connective tissue grafts prior to grafting. *H*, Coronal flap is undermined with an Orban knife to release and permit coronal movement. Note movement of the flap. *I*, The grafts and flap are sutured and stabilized occlusally. *J*, After healing. Compare with *D*. *K*, Final prosthetic case. Note the excellent esthetic result and root coverage of tooth 11.



FIGURE 24-3. Papillary reconstruction using a subepithelial connective tissue graft. Azzi technique. A and B, Before, showing the papilla 5 mm below the cemento-enamel junction with significant recession on teeth 10 and 11. A' and B', Before, showing excessive spacing between and under the pontics. C, C', Grafts positioned and flaps sutured and coronally positioned. Flaps are sutured and coronally positioned near the cemento-enamel junction using coronal suturing. D, D', Final result with significant space closure and root coverage on teeth # 10 and #11 and almost 100% ridge enhancement. Final results 8 months later. Compare with A and B and A' and B'.

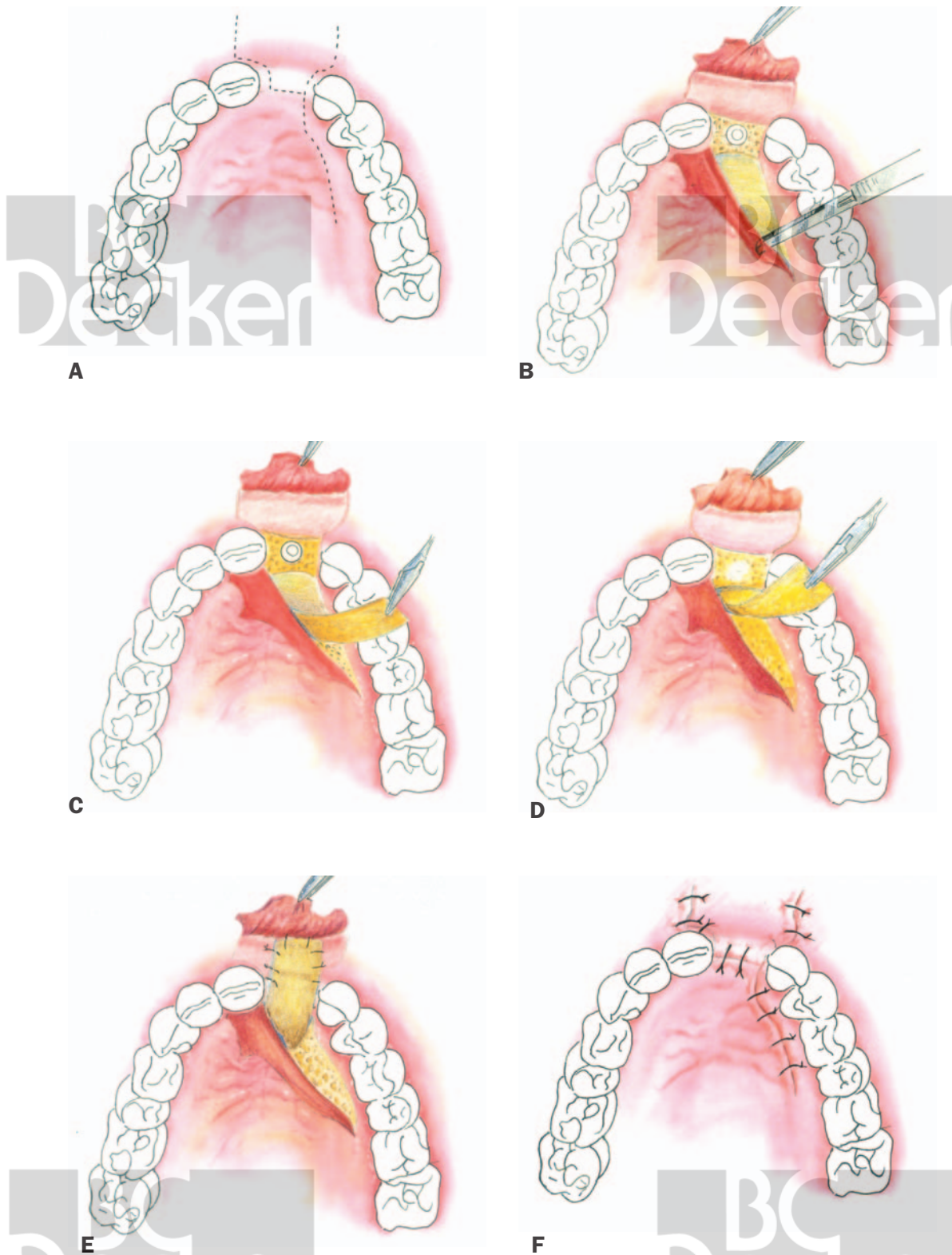


FIGURE 24-4. Pediculated connective tissue graft (PCTG). *A*, Before; occlusal view with incisions outlined. *B*, Partial-thickness palatal flap and buccal pouch or flap are reflected. *C*, The connective tissue graft is begun distally and carried forward. *D*, The graft is undermined and extended into the edentulous area. *E*, The PCTG is rotated or folded over onto the buccal surface and sutured. *F*, The flaps are closed over the graft and donor sites.

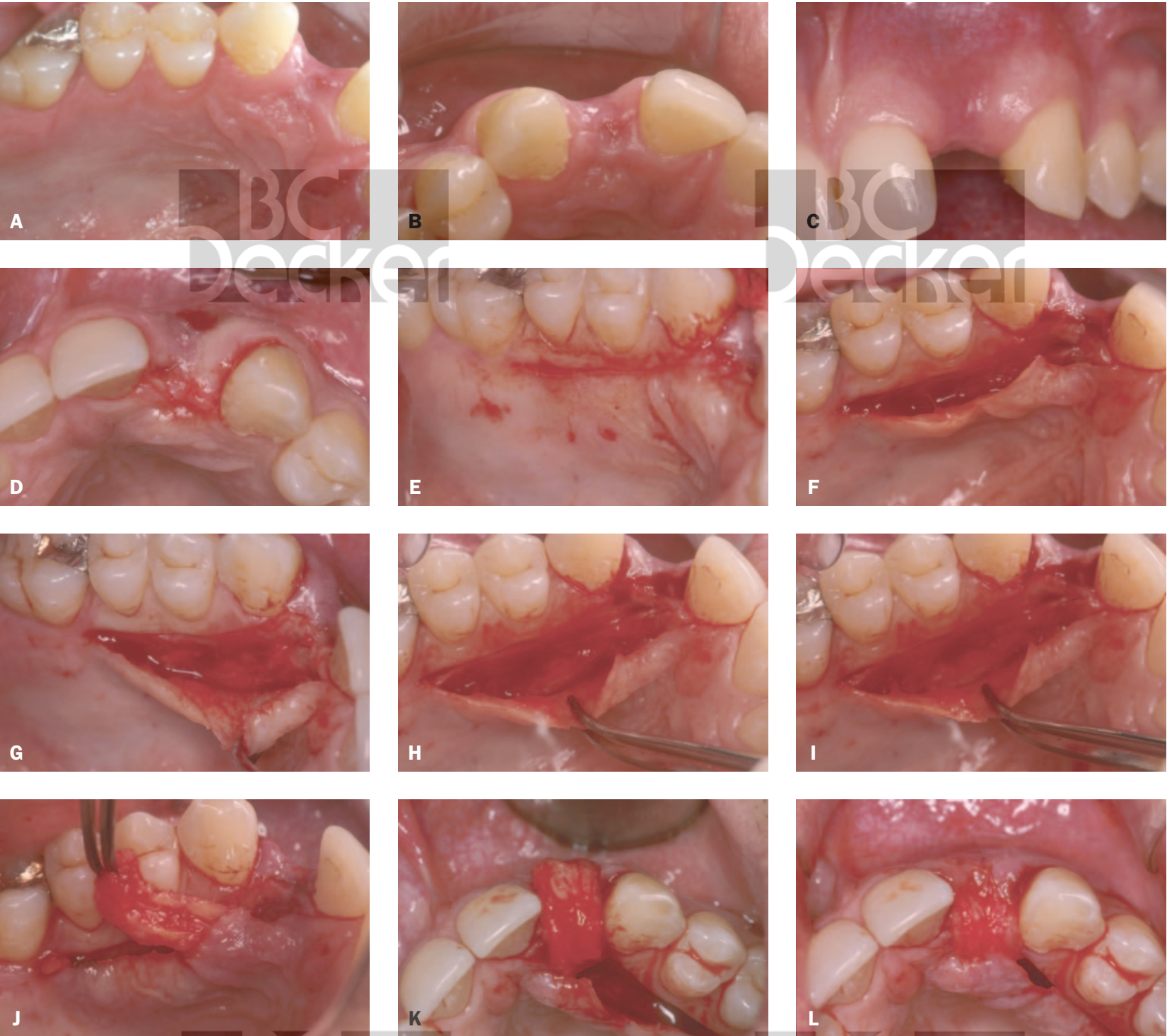


FIGURE 24-5. Pediculated connective tissue graft (PCTG). A and B, Before view of the palate and edentulous area. C, Buccal view showing loss of bone. D, Initial buccal pouch incisions. E, Initial horizontal palatal incision. F, Primary thinning incision extended anteriorly. G, Flap reflected for apical releasing incision. H, Apical releasing incision completed. I, The PCTG is released by blunt dissection and undermined anteriorly. J, The graft is lifted and reflected anteriorly. K, The pedicle is rotated or folded over onto the edentulous area. L, The anterior end of the pedicle is placed in the pouch.



FIGURE 24-5. *Continued.* M, Buccal view of the graft position. Note the correction of bony dehiscence. N and O, Edentulous area and palate are sutured. P and Q, Four months later; buccal and occlusal views. R and S, Final temporization; buccal and occlusal views. Note the excellent esthetic results with ideal papillary form achieved.



FIGURE 24-6. Pediculated connective tissue graft (PCTG). A and B, Preoperative clinical views. C, Temporization prior to treatment. D, Extraction completed. E, Palatal view before treatment. F and G, Palatal incision complete and tissue rotated over the extraction socket. H, Palate sutured. I, Connective tissue pedicle sutured in the pouch. J, Ovate pontic already established at the time of crown lengthening. K and L, Final case. Compare with preoperative views. Note excellent papillary form between teeth 7 and 8.

Surgical Exposure of Impacted Teeth

The clinician is often called on by the orthodontist for exposure of an impacted tooth. The surgical techniques required are similar to those used for basic periodontal surgery (see the appropriate chapters for techniques):

1. Gingivectomy: buccal exposures with adequate keratinized gingiva only
2. Partial-thickness flap: labial or buccal exposures
3. Full-thickness mucoperiosteal flap: palatal and lingual exposure
4. Osseous surgery: tooth exposure

The maxillary and mandibular third molars are the most commonly impacted teeth owing to their long development time (Erikson, 1938; Fastlicht, 1959). The maxillary cuspid is the second most frequently impacted tooth (2%) (Bass, 1967) and is most often (2:1) impacted palatally (Johnston, 1969; Gensior and Strauss, 1974). The cuspids are generally one of the last teeth to erupt into the arch and are adversely affected by (Smukler and colleagues, 1987):

1. The loss of space
2. Overretained deciduous teeth
3. Deflection facially or palatally off the lateral incisor

Historical Review

Historically, a number of methods have been described for exposure of the impacted teeth:

1. Celluloid crown (Stock, 1938)
2. Pack the wound area to maintain exposure (Clark, 1971)
3. Recommended gutta-percha packing (Von der Heydt, 1975)
4. Pins (Prescott and Boldberg, 1969)
5. Orthodontic bands (Hunter, 1983)
6. Wire ligature (Ziegler, 1977)

The three most significant advances historically for exposure were

1. Palatal flap for exposure (Lappin, 1951)
2. Direct bonding brackets (Gensior and Strauss, 1974)
3. Soft tissue management (Vanarsdall and Corn, 1977)

The palatal flap provided access and visibility. Direct bonding reduced morbidity by minimizing wound size and reduced tissue overgrowth and additional surgeries by having the bracket placed at the time of exposure. Soft tissue management maintained and permitted an increase in keratinized gingiva, eliminating needless secondary surgery to treat mucogingival problems and prevent recession. As Vanarsdall and Corn (1977) pointed out, “the surgical approach called the simple exposure (Clark, D. 1971) appears to lack an appreciation of the histologic characteristics of the overlying soft tissue involved.”

Diagnosis

There are three commonly used methods for diagnosis of the position of the impacted cuspid:

1. Palpation
2. Radiographs
3. Transgingival probing (TGP)

Palpation

Labial impaction is often visibly discernible as a bulge on the labial aspect or in the mucobuccal fold. Digital palpation will reveal a localized, hard, well-circumscribed, oval-shaped body just beneath the tissue.

Radiographs: The Buccal Object Rule

The rule states that when two different radiographs (one straight and one angulated mesially or distally) are taken of a pair of objects, the image of the buccal one moves, relative to the image of the lingual object, in the same direction as the x-ray beam is directed (Richards, 1980). Clark (1910), in his original article, advocated three radiographs (straight, mesial, distal) for a final determination (Figure 25-1 and 25-2).

Transgingival Probing

Although radiographs will provide a general area of impaction, TGP will provide an exact location.

TGP is conducted at the time of surgery after administration of local anesthesia using a 30-gauge needle to probe the area. A 27-gauge needle is sometimes required if the impaction lies in a bony crypt (the 30-gauge needle is too flexible for osseous penetration).

The area of the impaction is probed until the exact position of the tooth is localized. This is determined by the difference in translation of the needle tip over bone and over enamel. *When the needle is in contact with the bone, it will stick and not slide. When in contact with the enamel of the tooth, it will slide or glide as if on a sheet of glass.*

Definitive localization will facilitate flap design, permitting a conservative surgical approach.

Note: The TGP will not work when the impacted tooth is covered by a thick and dense layer of bone that the needle cannot penetrate.

Procedure

General Principles

1. The surgical procedures outlined for the impacted cuspid are applicable to all impacted teeth.
2. All procedures use the following common elements:
 - a. Local anesthesia: 1:100,000 or 1:50,000 epinephrine
 - b. TGP for tooth localization
 - c. The exposed tooth surface is cleaned sufficiently with sealers or rotary instruments to permit bracket bonding.
 - d. Ultraviolet light or autopolymerizing bonding agents are recommended

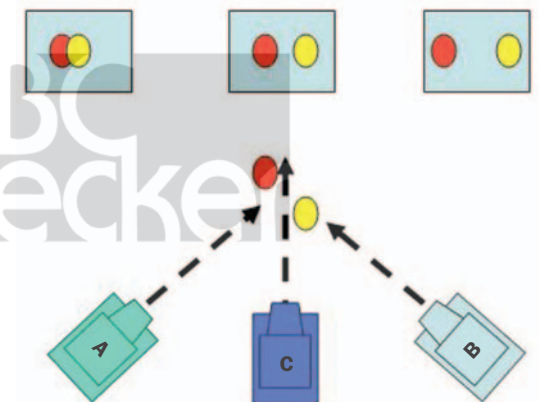


FIGURE 25-1. Diagrammatic representation of Clark's rule. A and B, represent the expected movements of the objects with angulation. C represents straight radiography.

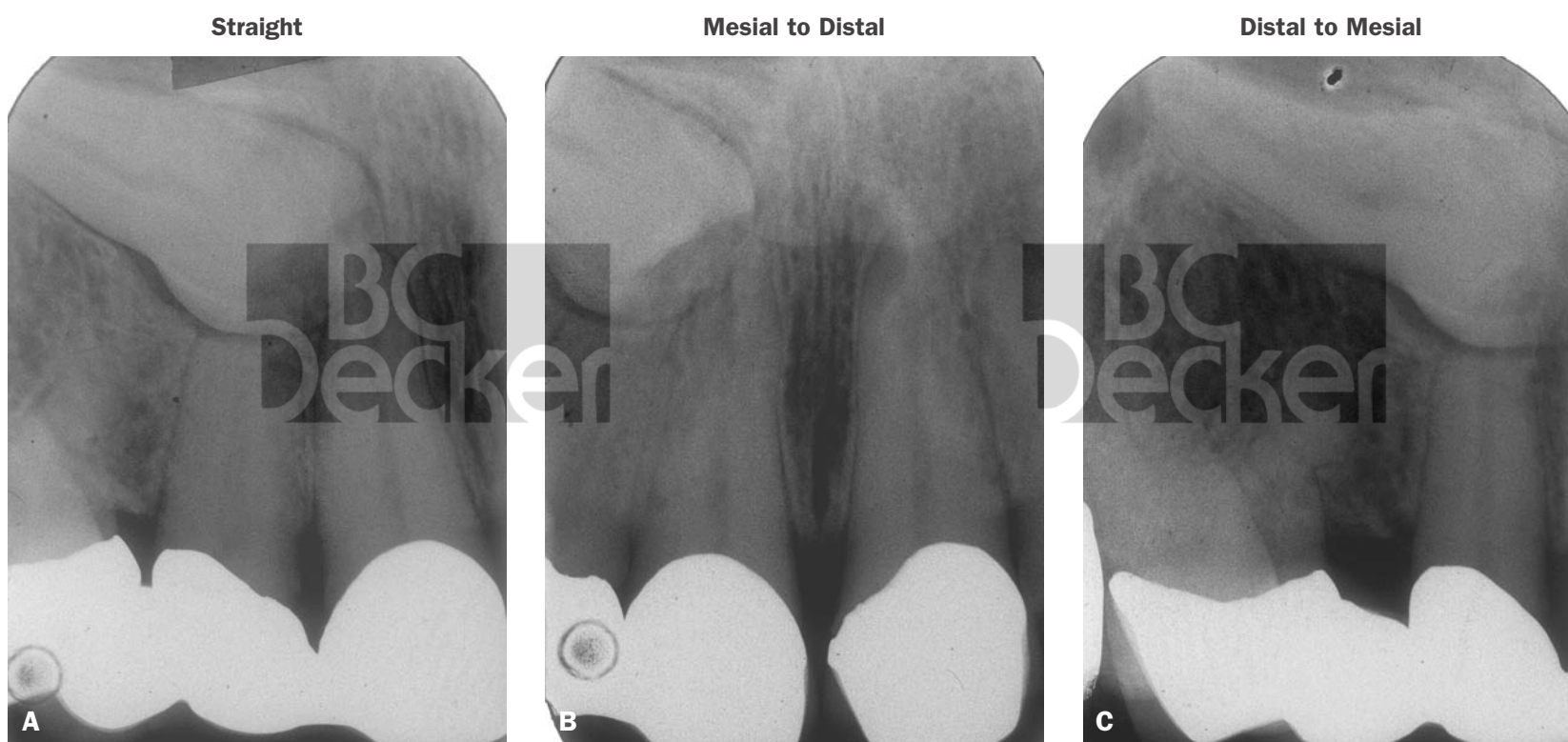


FIGURE 25-2. Radiographic examination for localization of an impacted tooth. A, Radiograph taken straight on. B, Radiograph taken mesial to distal. C, Radiograph taken distal to mesial. Note movement of the tooth with the change in angulation.

- e. Bracket placement
- f. Wire tie-in to arch wire
- g. 4-0 (or) 5-0 silk or chromic sutures with a P-3 needle
- h. Periodontal dressing

Note: This surgery is generally conducted on young patients.

The use of chromic sutures and periodontal dressings is recommended to decrease the post-operative problems and avoid the need for suture removal.

Labial Position

Gingivectomy. This is generally not the procedure of choice and is used only in limited situations.

Indications.

1. Impaction if positioned above the mucogingival line
2. A wide zone of keratinized gingiva exists
3. Excision will still result in a minimum of 2 to 3 mm of keratinized gingiva apical to the cementoenamel junction of the impacted tooth.

Contraindications.

1. Inadequate zone of keratinized gingiva
2. Access to the underlying bone is required
3. Tip of the impacted tooth is at or below the mucogingival line

Procedure.

1. With a Kirkland knife or no. 15 scalpel blade, the tissue over the crown is removed.
2. Only a sufficient amount of tissue to permit bracket placement is removed.

Note: It is always better to be more conservative.

Apically Position Partial- (Split) Thickness Flap. This is the procedure of choice for soft tissue management.

Indications.

1. Treatment and prevention of mucogingival problems
2. Precise flap stabilization and positioning are required
3. Extensive osseous surgery is not required

Contraindication.

1. A need for extensive osseous surgery

Procedure.

1. A split-thickness flap is raised by sharp dissections using a no. 15 or no. 15C scalpel blade.
2. The vertical releasing incisions are carried high enough into the vestibule to permit apical or lateral repositioning of the flaps.
3. The flap should be wide enough to maintain adequate vascularity.
4. The flap is raised to permit the exposure of an adequate amount of tooth structure to permit bracket placement.

Note: Unless the tooth is fully exposed, there is no need to achieve complete tooth exposure.

5. The impacted tooth is cleaned and scaled to permit bonding.
6. An orthodontic bracket or button is bonded to position.
7. The flap is apically positioned and stabilized with 4-0 or 5-0 chromic gut interrupted sutures (Figures 25-3 to 25-5).

Note: The vestibular sutures should engage the periosteum if possible to ensure greater flap stability.

Palatal Position

The cuspid is generally positioned in one of the following positions (Kokich and Mathews, 1993).

1. Intra-alveolar—vertically within the edentulous area
2. Horizontally
3. Apical to the lateral and central incisors

In the edentulous area tipped mesially against the lateral incisor

Intra-alveolar Position. It is not uncommon to find the impacted cuspid vertically positioned intra-alveolarly in the edentulous area. Buccal or palatal exposure is not recommended for these teeth owing to the excessive amount of bone removal that would be required.

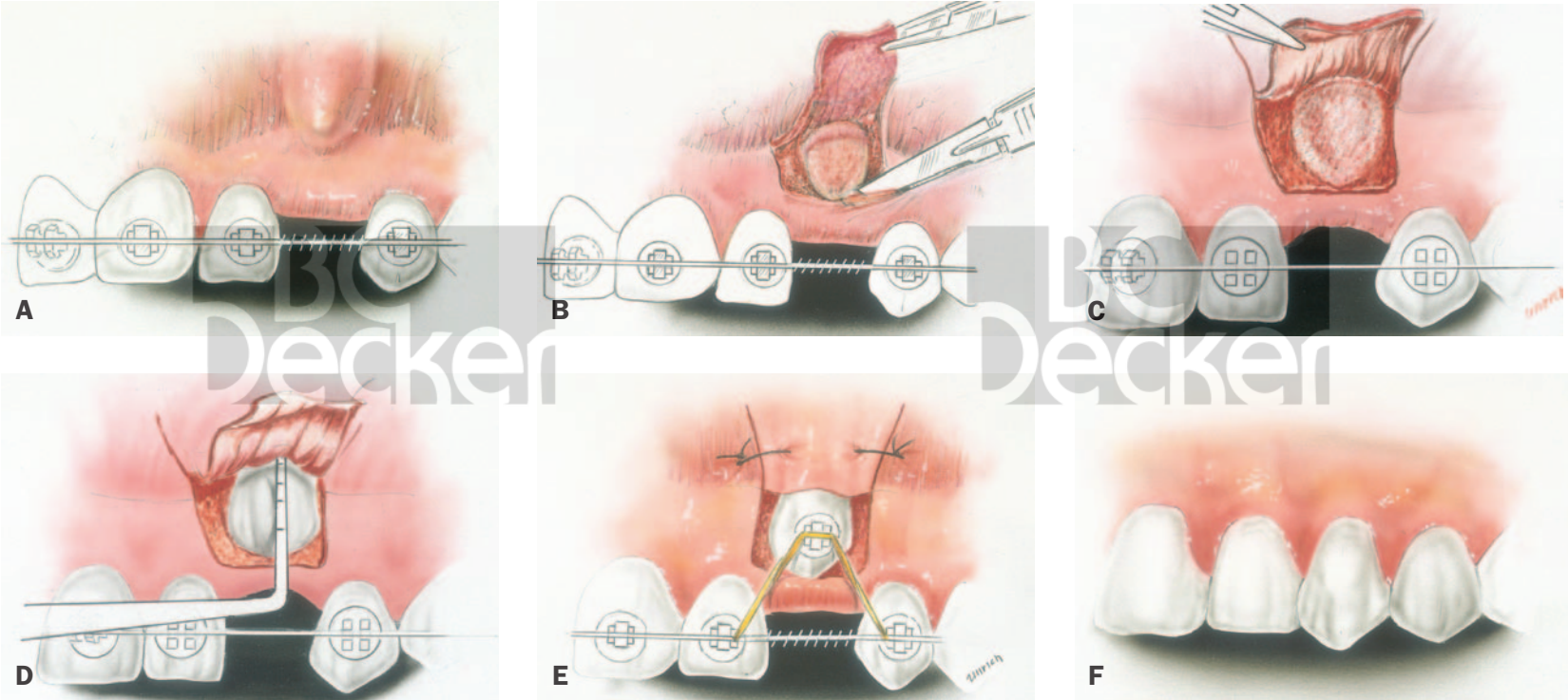


FIGURE 25-3. Buccal cuspid exposure. A, Initial view. B, Sharp dissection for partial-thickness pedicle flap and preservation. C, Cuspid exposed. D, Residual tissue and/or bone is removed for adequate exposure. E, Pedicle flap sutured apically with 4-0 or 5-0 chromic periosteal sutures. F, Case completed.

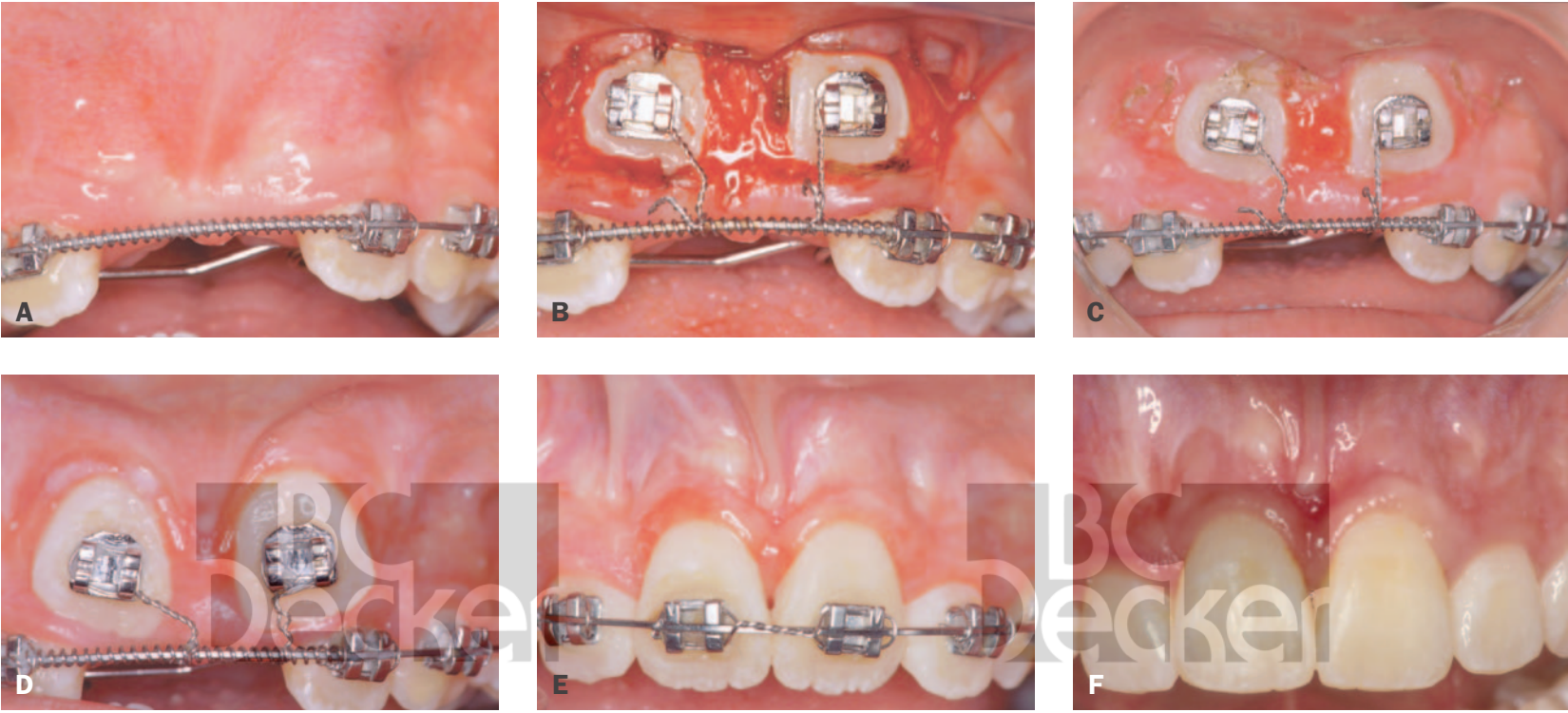


FIGURE 25-4. Buccal exposure of maxillary central incisors. A, Initial view. Note the large frenum present. B, Pedicle flaps apically positioned and sutured to periosteum with 5-0 chromic sutures. C, One week postoperatively. Note tie-in of brackets to arch wire. D, One month. E, Final position achieved. F, Final case. Note frenum displacement and the functional zone of keratinized gingiva.

Procedure.

1. A crestal incision is performed over the crest of the edentulous ridge with a no. 15 or no. 15C scalpel blade.
2. A mucoperiosteal flap is reflected with a periosteal elevator buccally and palatally.
3. The bone is exposed for 2 to 3 mm beyond the osseous crest.
4. The flaps are tied back to aid in exposure and bracket placement.
5. The tooth is now fully exposed and the dental sac is enucleated from the bony crypt by sharp dissection aided by curets (Smukler and colleagues, 1987).
6. Osteotomy, if necessary, is carried out with high-speed rotary instrumentation, remov-

ing only enough bone to provide for bracket placement.

7. After bracket placement and wire tie-in, the flaps are sutured over the edentulous area.

Note: Often tooth exposure is not possible and only the wire is visible. This is not a problem (Figure 25-6).

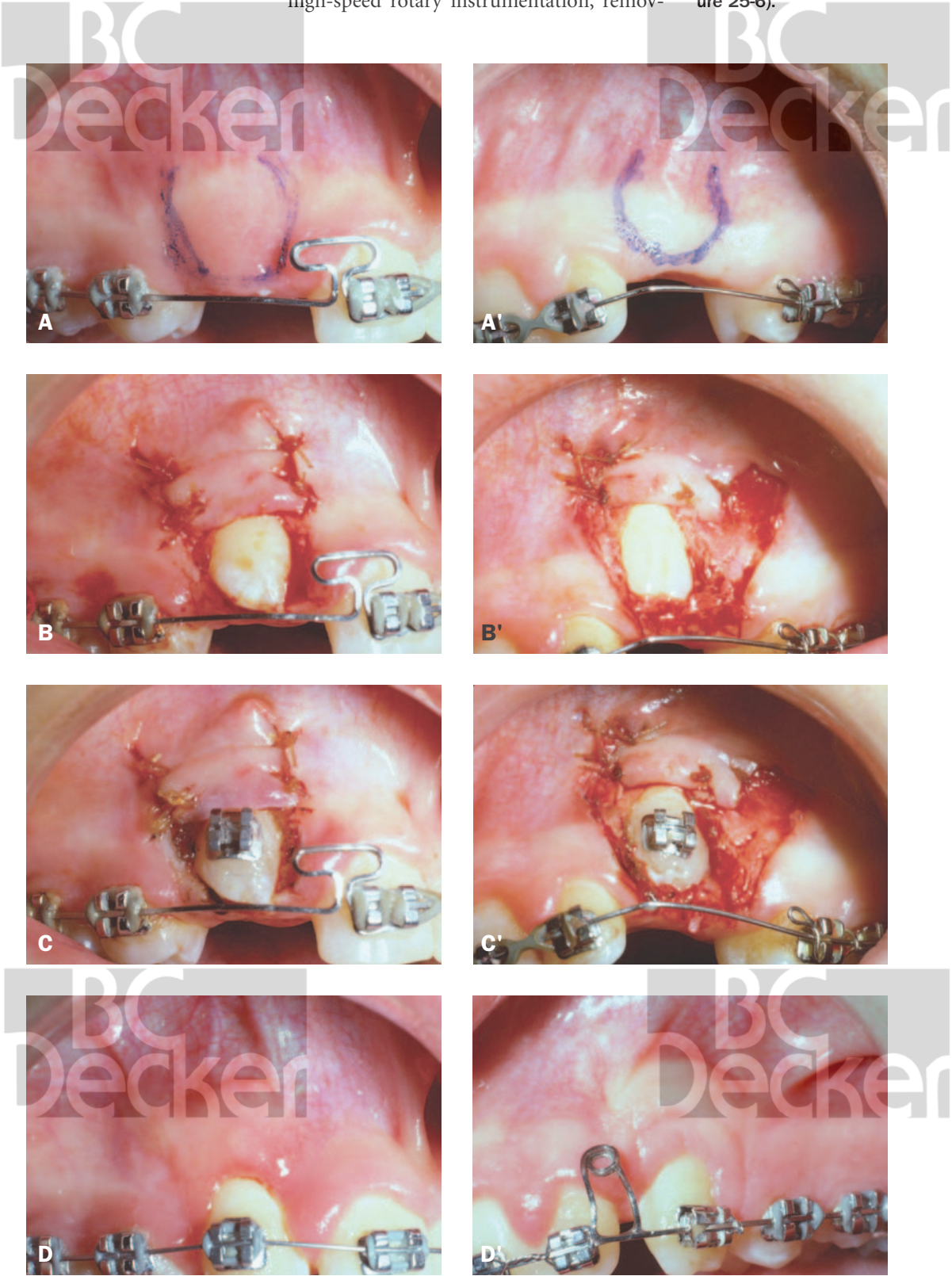


FIGURE 25-5. Exposure of buccal cuspid. *A* and *A'*, Preoperative clinical views of cuspids. *B* and *B'*, Apical positioning and suturing of the pedicle flap. *C* and *C'*, Bracket placement for tie-in. Note that bracket placement permits minimal surgical exposure. *D* and *D'*, Final case. Note the wide zone of keratinized gingiva.

Palatal Position. This is the most common position and the most difficult to treat. Proper surgical technique, presurgical tooth location, and an adequate flap reflection will facilitate tooth exposure.

General Considerations. There are two procedures for tooth exposure:

1. Full-thickness mucoperiosteal flap from the bicuspid to midline (Lappin, 1951; Kokich and Mathews, 1993)
2. Submarginal semilunar or trapezoidal flap (Smukler and colleagues, 1987)

Note: This technique requires “definitive” preoperative tooth localization. It has a greater degree of difficulty than the full-thickness flap, less margin of error, and the potential to damage the palatal artery when the impaction approximates the palatal vault.

Procedure

A. FULL-THICKNESS MUCOPERIOSTEAL FLAP.

1. Intrasulcular or submarginal incisions are carried out with a no. 15 or no. 15C scalpel blade from the bicuspid to the midline.
2. A full-thickness flap is raised to the palatal vault with a periosteal elevator and the flap is ligated to the opposing arch for retraction.
3. Continue at C (post-flap reflection and ligation procedures).

B. SEMILUNAR OR TRAPEZOIDAL FLAP.

1. Using a no. 15c scalpel blade, a semilunar incision is made starting mesiopalatal to the

impacted tooth and finishing distopalatally. This will permit elevation of the flap with unimpeded access to the impacted tooth and to adjacent bone.

2. The U-shaped incision should pass through the edentulous area if possible.
3. The intact marginal areas of the adjacent teeth should be avoided.
4. The scalpel blade should be angled to obtain a long bevel, which will facilitate flap closure.
5. A full-thickness mucoperiosteal flap is reflected with a periosteal elevator, which is ligated to the opposing arch for retraction.
6. Continue at C (postflap reflection and ligation procedure)

C. POST-FLAP REFLECTION AND LIGATION PROCEDURES

1. The roof of the bony crypt, if present, is gently removed with hand and rotary instrumentation.
2. The dental follicle or sac is removed by sharp dissection and hand cures.
3. The walls of the bony crypt are only widened enough to provide access for bracket placement.
4. Tooth mobility is tested with an instrument. If there is no movement, an attempt is made to luxate and loosen it within the alveolus with an elevator.
5. The position of the tooth in the crypt is noted. This will be helpful for the orthodontist during tooth movement. An attempt (not always possible) should be made to

place the bracket in a position that will facilitate favorable orthodontic tooth eruption.

6. Bracket or button placement is the most difficult part of the procedure owing to bleeding. Bleeding can be controlled by
 - a. Intraosseous injection of local anesthesia of 1:50,000
 - b. Packing the area with impregnated (1:50,000) gauze
 - c. Sterile bone wax burnished into the bony crypt
 - d. Proper suction technique: The tip is positioned where the bleeding is emanating from, close enough to control the bleeding but not so close as to affect the bonding agents.

Note: All instruments for bracket placement should be ready for immediate use once the tooth has been isolated and bleeding controlled.

7. The bracket bond is tested after the wire is attached.

FLAP CLOSURE. FULL-THICKNESS MUCOPERIOSTEAL FLAP (KOKICH AND MATHEWS, 1993).

1. The flap is returned to its original position.
2. The flap is palpated to locate the bracket.
3. A no. 15 scalpel blade is used to fenestrate the flap for bracket exposure
4. The flap is sutured with a continuous sling suture
5. The wire is now attached and tied in

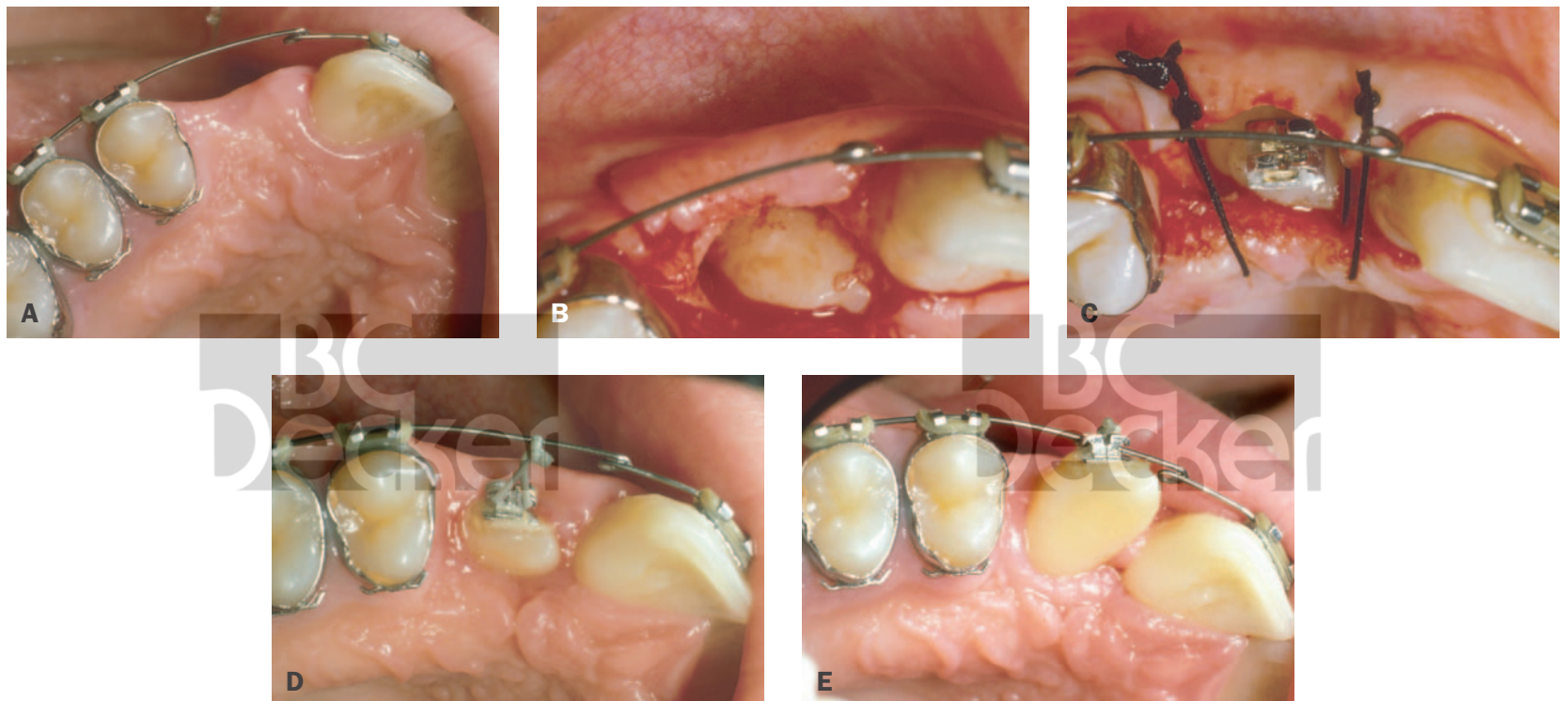


FIGURE 25-6. Midridge exposure of an impacted cuspid. A, Initial occlusal view. B, Buccal palatal flaps raised and area degranulated for exposure. C, Bracket placed and area sutured. D, Bracket used for initial movement. E, Case near completion.

SEMILUNAR FLAP.

1. The flap is replaced after wire placement
2. A no. 15 scalpel blade may be used for bracket exposure prior to final suturing.
3. The flap is sutured.

Note: Bracket exposure and wire tie-in at the time of surgery is the treatment of choice. This will minimize post treatment problems if the bracket is lost.

COMPLICATIONS

1. Loss of bracket—0 to 5%
2. Infection—none reported. Clinical examples are shown in Figures 25-7 and 25-8.



FIGURE 25-7. Palatal exposure of an impacted cuspid. Full thickness mucoperiosteal flap. A, Initial palatal view. B, Full thickness flap reflected. C, Bracket positioned. D, Flap replaced and sutured. E, Bracket exposed and ligated to facial arch wire. Suturing completed. F, Two weeks later healing almost complete.

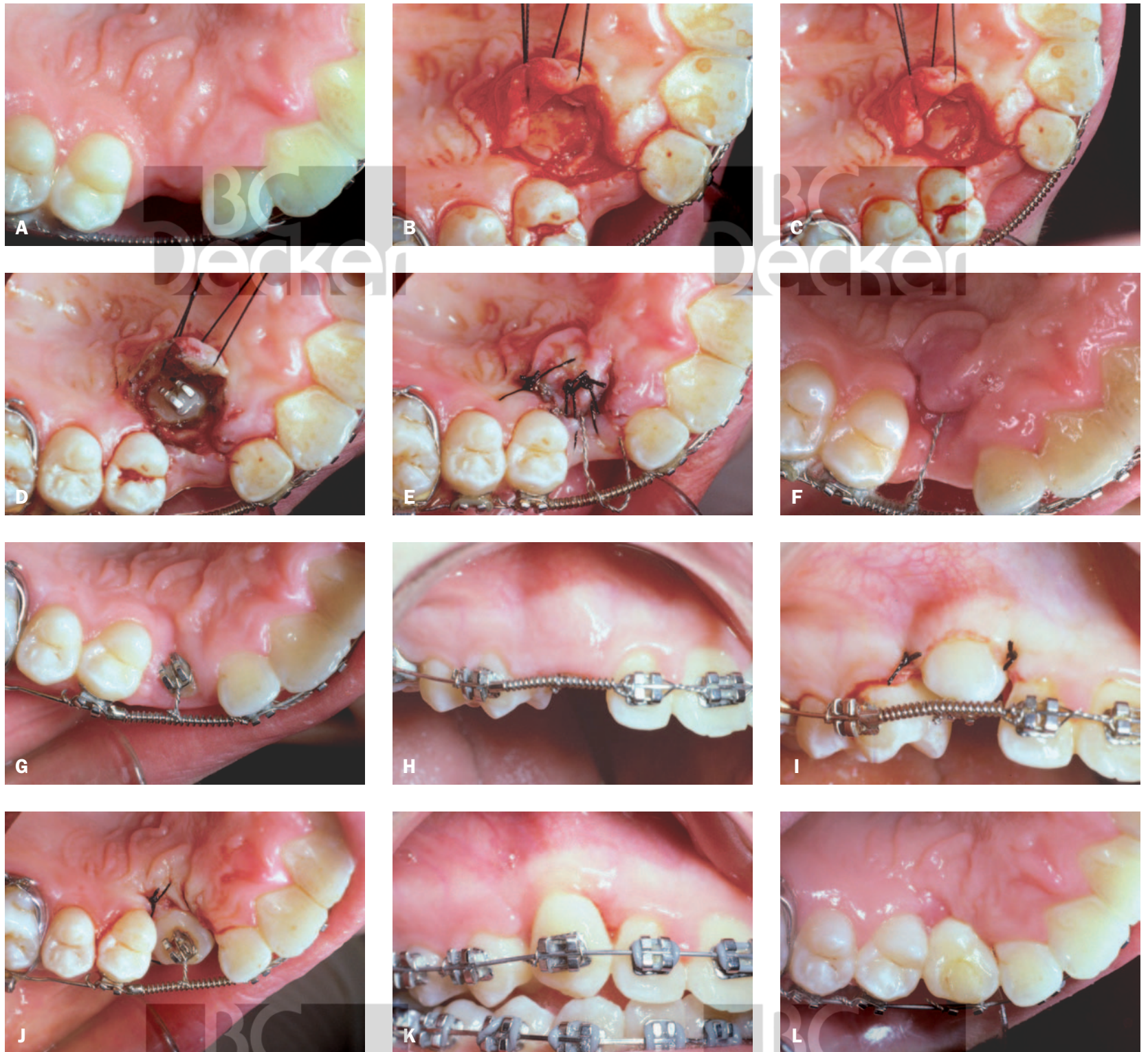


FIGURE 25-8. Palatal exposure of an impacted cuspid. *A*, Initial palatal view. *B*, Localized flap reflected over impaction. *C*, Tissue and bone removed from the impacted tooth, creating a window. *D*, Orthodontic bracket is placed. *E*, Bracket is tied into arch wire and the flap is sutured. *F*, One month later. Note complete coverage of the bracket. *G* and *H*, Palatal and buccal views of the impacted tooth in the correct position but covered with tissue. *I* and *J*, Buccal and palatal views at the time of removal of excessive gingival tissue. *K* and *L*, Final buccal and palatal views.

The Osteotome Technique

Implants have expanded our prosthetic options and become the cornerstone for posterior edentulous rehabilitation. They have provided a stable platform from which to build fixed or removable appliances, and whereas surgical placement of an implant in the mandible presents few surgical limitations (inferior alveolar nerve), the posterior maxilla presents a variety of surgical dilemmas:

1. Type III to IV bone quality (Zitzmann and colleagues, 1985; Jaffin and Bermann, 1995)
2. Variability in bone quality (Zitzmann and Schärer, 1988; Misch, 1990)
 - a. Fatty tissue
 - b. Fibrous inclusions
 - c. Voids
3. Thinning or missing cortex (Jaffin and Berman, 1991)
4. Insufficient posterior bone height (Chanavertz, 1990, 1995; Smiler and colleagues, 1992; Coatam, 1997a, 1997b; Smiler, 1997)
 - a. Pneumatization of the sinus
 - Increased positive pressure
 - Osteoclastic activity of the basement membrane of the schneiderian membrane
 - b. Periodontal disease
 - c. Removable prosthetics
5. Traumatic surgery
6. Spiny ridges (Adell and colleagues, 1981, 1990)
7. Undercuts (Bahat, 1993)

In Chapter 27, “Sinus Elevation Surgery,” the Caldwell-Luc lateral osteotomy is outlined. This section presents a conservative but equally effective approach for sinus augmentation and implant placement in the posterior maxilla: the osteotome technique.

The osteotome technique was originated by Summers (1994), and although a modification of the Tatum (1977), the crestal approach to sinus elevation does not permit exposure of the sinus membrane. *This technique, unlike the crestal sinus approach, attempts to reposition the existing crestal bone under the sinus, along with graft materials, thus elevating the sinus floor and increasing osseous support for the implant (Summers, 1994).* The osteotome technique is more conservative and less traumatic than some of the other recommended procedures:

1. Lateral osteotomy
2. Ridge onlay grafts

3. Split ridge osteotomy
4. Guided bone regeneration (GBR)

The technique results in reduced

1. Morbidity
2. Healing time
3. Surgical procedures
4. Cost
5. Postoperative complications

Summers (1994) developed the osteotome technique because of problems associated with drilling the maxilla and to improve implant positioning. Unlike routine implant placement, which requires removal of bone by drilling, the objective of the osteotome is to maintain all of the existing bone and to relocate it laterally or in a superior direction. Soft, spongy bone is compressed, providing better initial fixation of the implant because of a denser osteotomy wall. The osteotome technique offers a safe and effective means for

1. Compacting maxillary bone
2. Expanding thin ridges
3. Elevating the sinus floor
4. Providing site development for future implant placement

Osteotome surgery allows more implants to be placed in varied sites with less trauma while avoiding complex surgical procedures.

Reiser and colleagues (2001) studied the osteotome technique in human cadavers and found that the sinus membrane could “predictably” be elevated 4 to 5 mm and well beyond (6–8 mm), with a minimum amount (24%) of perforation (Table 26-1). They stated that most perforations were associated with septa.

They attributed their success to the following:

1. Careful presurgical radiographic analysis
2. Using a 2 mm twist drill to carefully drill to within 1 mm of the sinus floor (*Reiser modification*)
3. Careful intrasurgical radiographic analysis for determining the proximity of the drill site to the sinus floor
4. Use of limited or controlled force to elevate the sinus floor with an osteotome
5. Partially filling the osteotomy in advance of implant placement to push additional bone into the tented area.

They concluded that the osteotome technique provides a predictable method for raising the sinus floor well beyond the 4 to 5 mm usually reported.

Nkenke and colleagues (2002), using endoscopy for verification of sinus elevation and perforations, found the sinus procedure to be safe. They felt that without visualization for detecting perforations, “elevation should be confined to an average height of 3 mm.”

Fugazzotto (2003), in his review of the literature (Table 26-2) on the osteotome technique, noted an overall implant success rate of 85 to 100% with a mean bone gain of ≥ 3.5 mm (range 1–7 mm). Although the success rate for implant placement is comparable to that of the lateral osteotomy, the mean bone gain is significantly less (≥ 3.5 mm vs ≥ 11 mm). This has led to wide variation in recommendations for when to use this procedure.

Emmerich and colleagues (2005), in a meta-analysis of 1,139 implants (eight studies), were able to determine the short-term clinical (≤ 3 years) success (96%) of implants.

Endoscopically placed osteotomes were similar to implants conventionally placed (in the posterior maxilla).

Summers (1994), although not recommending a minimum subantral residual bone height, did state that 99 of 143 implants were ≥ 13 mm (no initial bone heights are provided). Misch (1999) recommended 10 to 12 mm, Jensen (1999) 7 to 10 mm, and Zitzmann and Schärer (1999) ≥ 6 mm for use of this procedure. Rosen and colleagues (1998), in a multicenter study, found that a minimum residual bone level of ≥ 4 mm was required to achieve a high rate of success (Table 26-3).

Table 26-1 Comparative Analysis of Elevated Sites with and without Perforation

Level of	Sites without Perforation	Sites with Perforation	
		Elevation (mm)	Class I Class II
4–5	9	1	0
6–8	10	2	3

Adapted from Reiser and colleagues (2001).
Perforations: Class I, < 2 mm; Class II, > 2 mm.

Table 26-2 Osteotome Articles Reviewed					
Study	Preoperative Sinus/Implants	Gain in Bone		Implant Time in Function (mo)	Cumulative Implant Success Rate %
		Alveolar Bone (mm)	Height (mm)		
Leblebicioglu et al	54/73	≥ 9	3.9	24 ± 6.4	97.3
Nkenke et al	14/18	6.8 ± 1.6	3.0 ± 0.8	6	89
Toffler*	167/267	3–10	2–7	1–84	94.6
	Mean 7.1	Mean 3.8	Mean 27.9		
		≥ 4			73.3
Summers	55/143	NR	NR	0–60	96.0
Horowitz	18/34	≥ 5	3.0	10–15	97.0
Coatoom and Krieger	77/89	NR	NR	6–4	92
Kornarnyckyj and London	16/16	3–9	2–7	3–38	95.3
	Mean 5.40	Mean 3.25			
Zitzmann and Schärer	20/59	≥ 6.0	3.5	30.0†	95.0
Rosen et al	101/174	≥ 5.0	NR	20.2†	96.0
		≤ 4.0			85.7
Deporter et al	16/26	≥ 3.0	NR	11.1†	100.0
Cavicchia et al	86/97	≥ 5.0	1–6	6–90	88.6
Localized management of the sinus floor‡					
Bruschi et al	303/499	5.0–7.0	NR	24–60	997.0
Winter et al	34/58	≤ 4.0	9.12	22.0†	91.4
Trephine/osteotome technique§					
Fugazzotto	103/116	NR	NR	32.7†	98.3

NR = not reported.

*Note: The failure rate for machined implant surfaces was significantly higher than the rate for rough-surface implants (13% vs 5.3%).

†Mean time in months.

‡This technique more closely resembles the Tatum (1977) crestal sinus lift procedure than the Summers osteotome technique.

§This procedure is more closely related to future site development than to the original osteotome technique.

These results were recently confirmed by Toffler (2004), who found a 73% success rate at ≥ 4 mm and 94.6 at ≤ 5 mm.

Deporter and colleagues (2000) placed “porous” implants in ≥ 3 mm of residual bone and, although recording a 100% success rate, were only able to place 6.9 × 4.56 mm (average) size of implants.

Therefore, it is important to note that it is not a question of what the minimum requirement of bone over the sinus floor is but what size of implant is required for long-term success in the posterior maxilla. This requirement will vary with

1. Bone quality

2. Number of implants being placed

3. Interarch space

4. Occlusion

5. Prosthetic rehabilitation requirements

6. Clinical judgment, technical ability, and experience

7. Implant surface quality (smooth, rough, porous) (Del Fabbro and colleagues, 2004; Wallace and Froum, 2004).

Note: Since short implants have their highest failure rate in the posterior maxilla (Jaffin and Berman,

1995), a minimum implant length of 10 to 11.5 mm should be considered. Further, since the mean bone gain is only ≥ 3.5 mm, the minimal residual bone recommended for this procedure is ≥ 6 to 7 mm. This will vary with the technical expertise and experience of the clinician to achieve consistently greater sinus elevation using this technique.

Note: The ≥ 6 to 7 mm recommendation is meant to be conservative.

The Osteotome Technique

The osteotome technique provides a simple, safe, and effective means of treating many complex surgical problems encountered in maxillary implant

Table 26-3 Survival Rate by Pretreatment Bone Height			
Pretreatment	Height (mm)	Implants Placed	Surviving %
4 or less	14	12	85.7
5 to 6	50	48	96.0
≥7	110	106	96.4

Adapted from Rosen and colleagues (1999).

surgery. Osteotomes have become part of the standard armamentarium for most implant surgeons, along with drills. Recent research has shown that the bone formed in the sinus from the osteotome sinus lift is of comparable quality to bone generated by other, more invasive procedures.

Osteotome Procedures

1. Nongrafted sinus floor osteotome procedure
- a. Osteotome sinus floor elevation (OSFE)
2. Grafted sinus floor osteotome procedures
- a. Maxillary osteotome augmentation technique (MOAT)
- b. Bone-added osteotome sinus floor elevation (BAOSFE)
- c. Future site development (FSD)

General Diagnostic Guidelines

All osteotome procedures that involve elevation of the sinus floor require the following:

Preoperative Phase.

1. Accurate preoperative determination of residual subantral bone is a basic requirement.
2. Radiographic analysis
- a. Panorex
- b. Periapical radiograph
- Long cone paralleling technique
- Radiographic grid (mm) for accurate bone measurements

Surgical Phase. Radiographic analysis: After initial preparation with a no. 1 osteotome or a 2 mm twist drill, a calibrated probe is inserted to verify sinus proximity.

General Surgical Guidelines

1. At no time during any osteotome procedure does the osteotome instrument enter the sinus. Entrance into the sinus may result in perforation of the sinus membrane and discontinuance of the procedure.
2. Primary implant stability is an absolute requirement.

Advantages

Bone Preservation.

1. Less traumatic: no heat owing to rotary instrumentation
2. Bone is retained as opposed to removal with drilling
3. Increases usable sites
4. Improves visibility for the surgeon
5. Reduces potential dehiscences, fenestrations, and crestal fractures as bone is moved laterally
6. Reduces the need for GBR
7. Improves bone quality by lateral condensation
8. Improves tactile sensation during osteotomy preparation compared with drills
9. Control of instrument penetration without the wobble effect caused by a torquing hand-piece.



FIGURE 26-1. Straight and offset osteotomes for implant placement. A, Straight osteotomes (3-I). B, Offset osteotomes

10. Straight-line access to the tuberosity in most patients

Bone Expansion.

1. Ability to place stable implants in type IV bone
2. Improves implant positions by 10 to 15° ridge osteotome expansion (ROE)
3. Sinus floor elevation (OSFE, MOAT, BAOSFE)
4. Alteration of the anterior or posterior sinus boundary
5. Future site development
6. Allows narrow ridges and limited areas to be used for implants
7. Three-dimensional relocation of bone by expansion and deepening of the ridge
8. Avoids additional complex surgical procedures
9. Esthetic enhancement by widening the ridge and creating root form prominence

Bone Condensation or Osteocompression. Lateral condensation improves bone quality adjacent to the implant, enhancing the bone-implant interface while resisting cervical bone resorption, gingival recession, and unfavorable changes in the implant-to-prosthesis ratio.

This improved bone density has been shown to have the following positive effects:

1. Improved primary implant stability (Yildirim and colleagues, 1998)
2. Improved success rate in type IV bone (Glauser and colleagues, 1998)
3. Earlier new bone formation (Nkenke and colleagues, 2002)

4. May permit earlier loading (Roccuzzo and Wilson, 2002)

Miscellaneous.

1. Less morbidity
2. Less cost
3. Less time than with staged procedures
4. Drilling and the osteotome technique can be combined effectively in a site during a single procedure

Limitations. The osteotome technique requires cancellous-type bone structure. Some drilling may be required in denser sites.

Nongrafted Sinus Floor Osteotome Procedure

Osteotome Sinus Floor Elevation (OSFE). The OSFE (Summers, 1994) is a very limited technique that permits the surgeon to place a slightly longer implant in a safe manner without the need for additional grafting.

Indications. OSFE is designed for modest changes of 1 to 2 mm in implant length. A minimum of 9 to 10 mm of bone should be present.

Contraindications.

1. When more than 1 to 2 mm of elevation is required, a graft material is required (MOAT or BAOSFE)
2. Dense bone that requires drilling

Procedure. The key to this technique is to accurately measure the height of the existing bone prior to OSFE and to control the depth of osteotome penetration. Osteotomes do not enter the sinus.

1. A small round bur is used to break through the outer bone cortex.
2. The osteotomes are used in sequential order to a maximum height of 1 mm below the sinus floor.

Note: The use of twist drills is contraindicated for this procedure, and, if required, another procedure should be chosen. Twist drills will remove the necessary bone to bend, flex, or greenstick fracture the sinus floor.

Bending or greenstick fracture of the sinus floor occurs as bone piles up in front of the tip of concave osteotomes. Shaved bone from the osteotomy walls and trapped fluids in front of the instrument tip create hydraulic force to flex up the bone at the sinus floor. Bone in this region is not true compact bone; therefore, it will bend with light malleting (Figure 26-2).

Grafted Sinus Floor Osteotome Procedures

Requirements.

1. Accurate preoperative radiographs to determine bone height

2. A minimum of ≤ 4 to ≥ 5 mm of bone is necessary between the maxillary crest and the sinus floor (Jensen 1996; Sinus Graft Consensus Conference Report, 1996; Rosen and colleagues, 1998; Toffler, 2004)
3. Primary implant stability

Contraindications.

1. Less than 4 mm of bone height
2. Sinus infection
3. Recurrent symptomatic sinus problems.

Maxillary Osteotome Augmentation Technique (MOAT). This is the recommended procedure of choice, especially for the less experienced clinician (Lazzara and colleagues, 1999; Cavicchia and colleagues, 2001; Toffler, 2004).

The original BAOSFE (Summers, 1994) has undergone a number of modifications since its introduction. The MOAT procedure has a number of benefits over the BAOSFE.

Advantages.

1. Simpler
2. Easier
3. Faster
4. Less morbidity (less malleting)
5. Reduced chance of membrane perforation with infraction
6. High predictability

Contraindications. In cases of very soft medullary or cancellous (type IV) bone, this procedure should not be used. The BAOSFE with or without the *Reiser modification* is the procedure of choice.

Limitations.

1. It does not permit the initial doming of the sinus floor that is achieved with the osteotomes (OSFE).
2. It reduces the amount of autogenous bone under the sinus membrane.
3. It will not permit closure of small perforations with autogenous bone.
4. It does not permit the lateral compacting of maxillary bone.

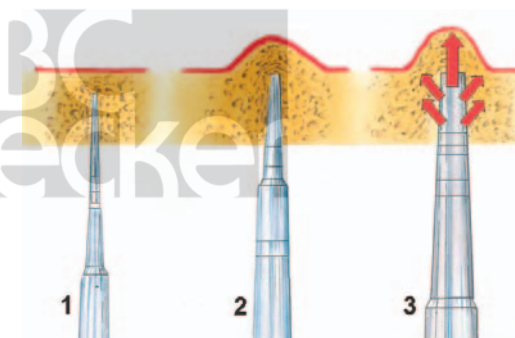


FIGURE 26-2. Osteotome sinus floor elevation. The use of increasingly wider osteotomes to just below the sinus floor. The concave tip will force bone superiorly, raising the sinus floor while also condensing the bone laterally.

Note: These limitations are not significant enough to justify not using this procedure except in type IV soft medullary bone.

Procedure

1. A full-thickness mucoperiosteal flap is reflected to allow full visualization of the site. All tissue tags and periosteum are removed from the crest and the lateral exposed wall of the alveolus.
2. A pilot drill is used to penetrate the cortex for 2 to 3 mm.
3. A 2 mm drill is used to within 1 mm of the sinus floor.
4. Radiograph verification of 2 mm drilling depth
5. 3 mm pilot drill
6. A 3 mm twist drill is used to within 1 mm of the sinus floor

Note: In cases of type IV bone, a no. 2 or 3 osteotome should be substituted for a no. 3 twist drill (Reiser modification).

7. Radiograph verification of 3 mm drilling depth

SINUS FLOOR ELEVATION

8. *Bone cushion technique.* A suitable graft material is now added to the osteotomy using the large end of a sterile amalgam carrier. The graft material will act as a shock absorber to gently infracture the sinus floor when the osteotome is inserted. **Note: This is the recommended technique.**
9. *Membrane insurance* (Toffler, 2004). This modification requires that the final infracture be accomplished without the use of a graft material cushion **Note: This is recommended only for only more experienced clinicians.** Once the fracture has been accomplished and the sinus checked by the Valsalva technique, a collagen sponge is inserted first as membrane insurance in case there is a small, nondetectable perforation. **Note: The use of the bone cushion technique does not preclude use of a collagen sponge after the initial infracture for membrane insurance.**

VALSALVA TECHNIQUE. The integrity of the sinus membrane can be confirmed by asking the patient to blow the nose while pinching the nostrils, placing a mirror over the osteotomy, and checking for misting. If the perforation is large, the procedure is stopped and can be repeated after 4 weeks of healing (Davaranah and colleagues, 2000). Toffler (2004) noted that Nkenke and colleagues (2002) recently showed the limited effectiveness of this test. Toffler (2004) pointed out that a number of studies (Boyne, 1992; Baumann and Ewers, 1999; Reiser and colleagues, 2001) have also shown spontaneous recovery of the sinus floor after small perforations.

GRAFT MATERIALS. A wide variety of graft materials can be safely used. A resorbable mineralized graft is preferred for the following reasons:

1. Resorbability
2. Osteoconduction
3. Osteoinduction
4. Radiographic confirmation of sinus elevation

Note: Bio-Oss or DFDBA are excellent alternatives to autogenous bone.

10. A no. 3 Summers osteotome (3I Implant Innovation, Palm Beach, FL) is used for infracture of the sinus floor after small loads of the graft mixture have been inserted into the osteotomy using the large end of an amalgam carrier. (bone-cushion technique). In difficult to reach areas, angulated osteotomes will facilitate fracture and graft placement.

Note: Each load of graft material will allow 1 to 1.5 mm of sinus lift.

11. As each load is inserted, the no. 3 osteotome is returned to the sinus floor. If difficulty is encountered, the surgeon can use the no. 2 instrument to obtain the required depth.
12. The graft material and fluids create hydraulic pressure, which raises the schneiderian membrane. Pascal's law of physics explains the widened tulip shape of the graft plug under the sinus membrane.
13. A 4 to 6 mm sinus lift can be consistently achieved (Reiser and colleagues, 2001; Lazzara, 2004).
14. Following graft placement, the final diameter of the osteotomy can be altered with insertion of the no. 4 or 5 Summers osteotome.
15. The implant is placed after the last load of material is inserted into the osteotomy. This allows the implant to perform the last stage of sinus elevation (Reiser and colleagues, 2001).
16. Implants placed at the time of MOAT require 7 to 8 months of healing.
17. Flap closure is identical to other conservative implant techniques. Single-stage systems can be used with results to equal to those of submerged implants.

Note: The osteotomes are sized so that the implants fit tightly and maximum initial fixation is achieved. The osteotomes are sized as follows

- | | |
|--------|--------------------------------------|
| No. 3: | for 3.3 to 3.75 mm–diameter implants |
| No. 4: | 4.0 to 4.25 mm–diameter implants |
| No. 5: | 4.8 to 5.0 mm–diameter implants |

Clinical examples are shown in Figures 26-3 and 26-4.

Bone-Added Osteotome Sinus Floor Elevation (BAOSFE). This technique is recommended for very soft cancellous or medullary type IV maxillary

bone. The MOAT technique or the Reiser modification is recommended for all other situations.

Procedure.

1. A full-thickness mucoperiosteal flap is reflected to allow full visualization of the site. All tissue tags and periosteum are removed from the crest and the lateral exposed wall of the alveolus.
2. A pilot drill and a no. 1 osteotome or 2 mm twist drill is used to penetrate the outer cortex of bone.
3. Hard malleting is to be avoided. A 2 mm twist drill may be used until softer bone is encountered. A drill may be employed as required to within 1 mm of the sinus floor.

Note: Drilling removes bone, so the drill should be used in a minimal manner. If drilling is required, then the MOAT or Reiser modification should be used.

4. If access is limited, an appropriately angulated osteotome should be employed.
5. The surgeon should advance the osteotome by 1 mm with each successive mallet stroke.
6. As the surgeon approaches within 1 to 2 mm of the sinus floor, a calibrated directional indicator is inserted into the osteotomy and a final accurate radiograph is taken. The indicator should stop approximately 1 mm short of the lamina dura, after which only widening of the osteotomy will take place.
7. To avoid binding, the osteotome should be kept moist and rotated a half-turn with each successive mallet.
8. Inadvertent sinus perforation is correctable with the judicious use of the no. 2 and 3 osteotomes, which are kept just short of the lamina dura.
9. A bone graft is now added to the osteotomy and use of a no. 3 Summers osteotome for fracture of the sinus floor and sinus elevation.

Note: All other procedures are the same as for the basic MOAT (steps 8–17).

Diagrammatic and clinical examples of the BAOSFE procedure are shown in Figures 26-5 to 26-7.

Future Site Development (FSD). When there is insufficient bone for performing the osteotome technique (≤ 4 mm of bone), primary implant stability is not possible, or the clinician requires a greater amount of bone than can be achieved with the osteotome technique, there are two options:

1. Caldwell-Luc lateral osteotomy technique
2. FSD osteotome technique

The choice of procedure will, as noted previously, be based on the functional and occlusal requirements of the patient and the technical ability and experience of the clinician.

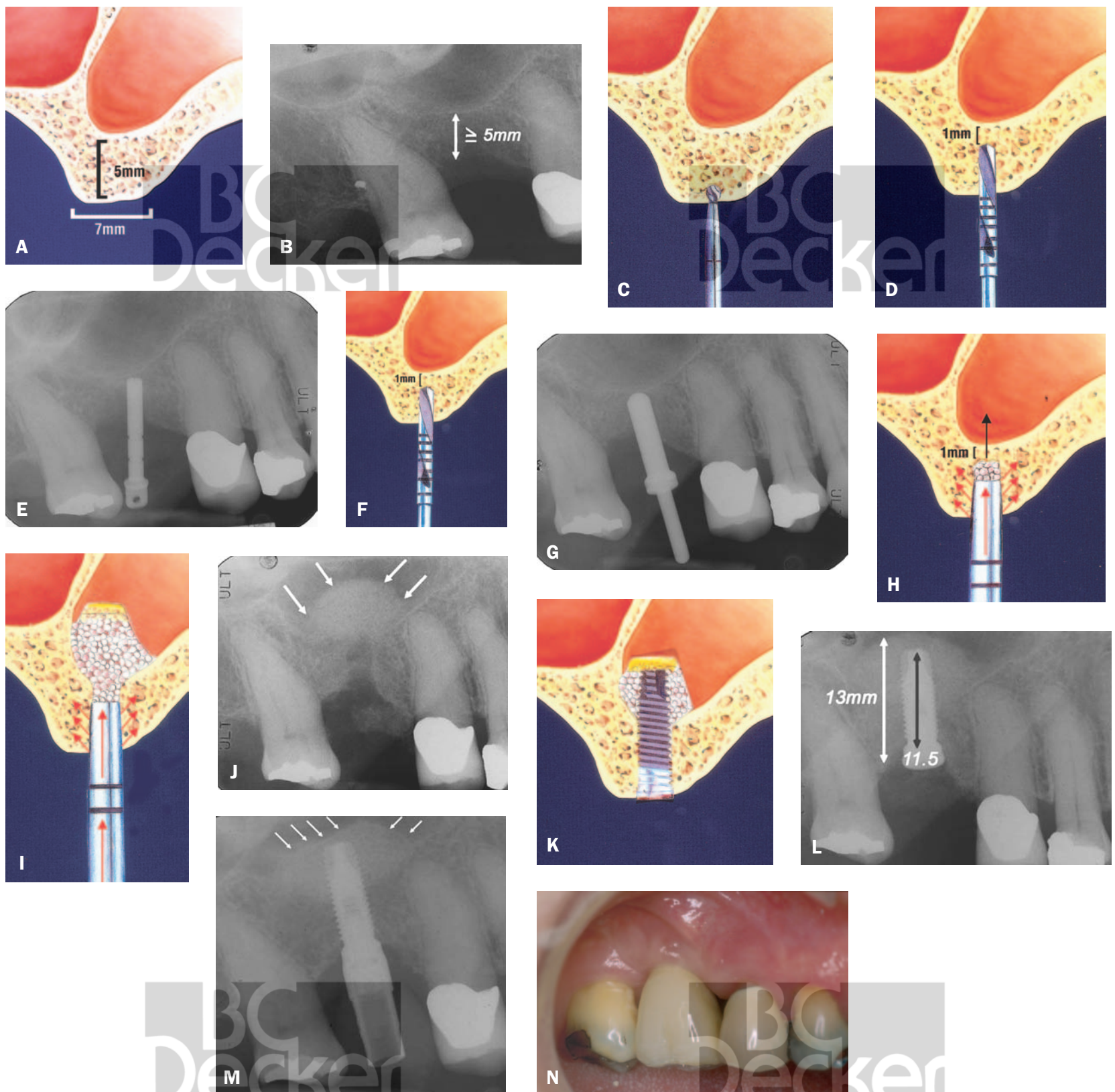


FIGURE 26-3. Maxillary osteotome augmentation technique. Basic technique. *A* and *B*, Preoperative diagrammatic and radiographic views showing a minimal requirement of ≥ 5 mm of alveolar bone under the sinus. *C*, Round bur used to form the initial breakthrough of bony cortex. *D*, A 2 mm twist drill is used to 1 mm below the sinus floor. *E*, A 2 mm probe is used to verify the initial 2 mm drill depth. *F*, A 3 mm twist drill is used to 1 mm below the sinus floor. *G*, A 3 mm probe is used for depth verification. *H*, Bone graft and osteotome positioned for initial greenstick infracture of the sinus floor. The graft material will act as a cushion. *I*, Sinus floor elevated with repeated graft insertion. Each load of graft material will raise the floor by 0.5 to 1 mm according to Pascal's law. Red arrows indicate later condensation of bone. *J*, Radiograph showing the smooth dome shape of implant material under the sinus membrane, indicating success and graft limitation. *K*, Diagram showing simultaneous implant placement. *L*, Radiograph showing a 7 to 8 mm increase in the sinus floor and placement of a 11.5 mm implant. *M*, A 10-month postoperative radiographic view after temporization. Arrows show a new sinus floor. *N* and *O*, Buccal and occlusal views of temporary crowns for progressive loading.

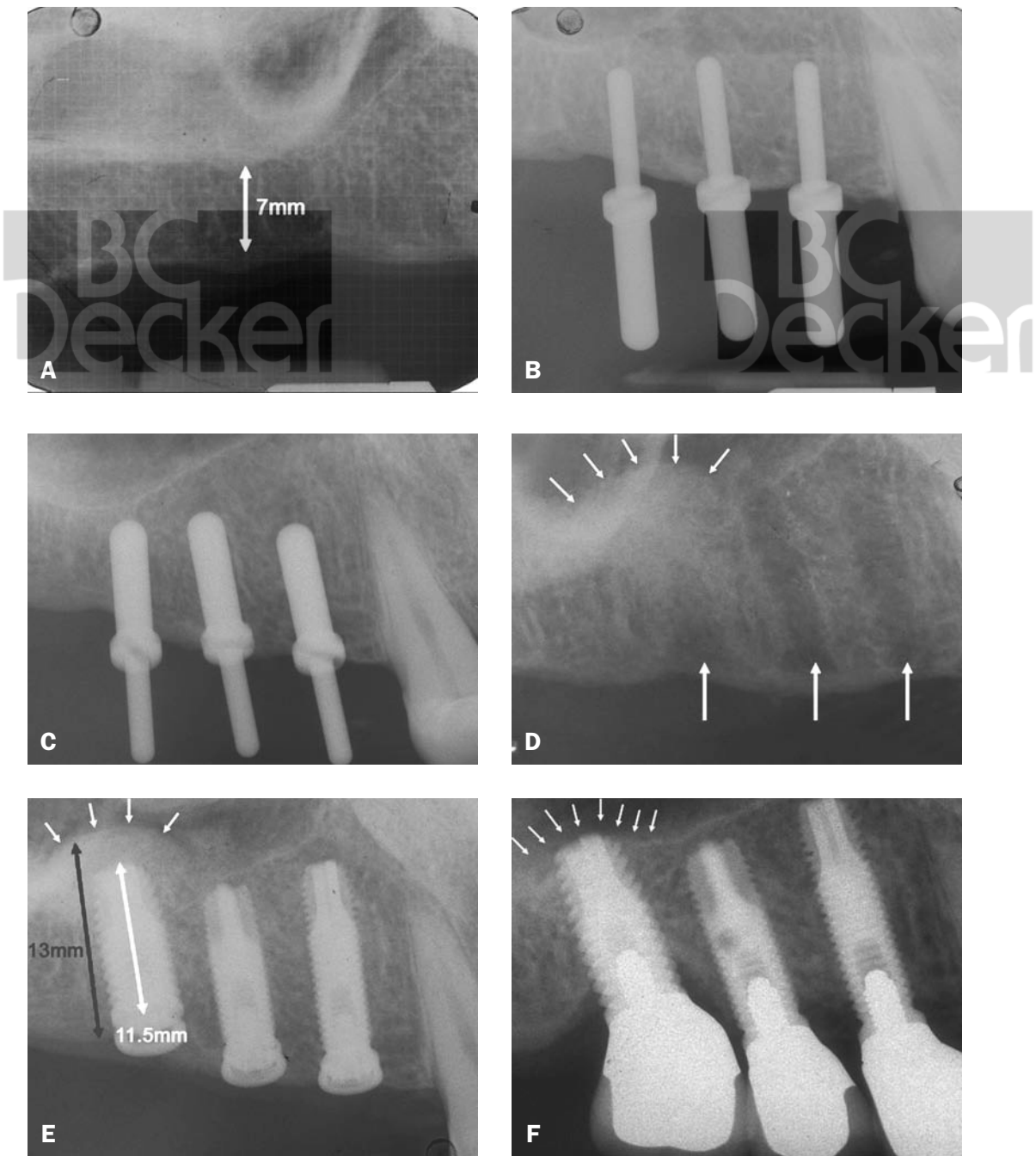


FIGURE 26-4. Maxillary osteotome augmentation technique. A, Preoperative view showing 7 mm of residual bone. B, A 2 mm twist drill is used to just below (1 mm) the sinus floor. C, A 3 mm twist drill is used to the sinus floor. D, Yellow arrows indicate 3 mm twist drill holes. White arrows indicate dome-shaped sinus augmentation. Note that the smooth dome shape indicates that the sinus has not been perforated. E, Five-month postoperative results. Note that the sinus is elevated 5 to 6 mm, providing 3 to 4 mm of additional implant length. F, Final case one year later.

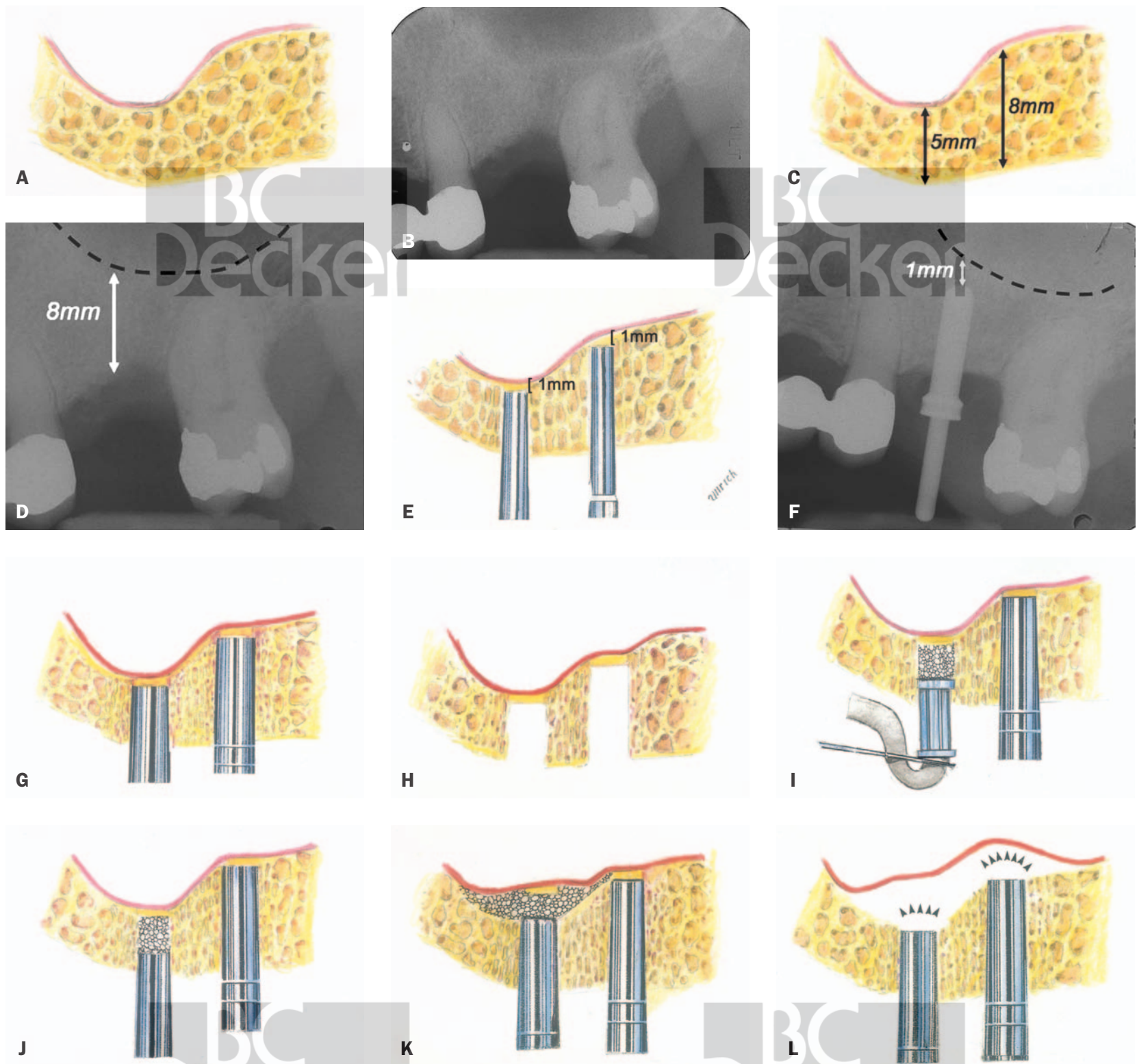


FIGURE 26-5. Bone-added osteotome sinus floor elevation, basic procedure. *A* and *B*, Diagrammatic and radiographic initial views. *C* and *D*, Diagrammatic and radiographic initial views showing inadequate vertical bone height for implant placement in the posterior maxilla. *E*, Osteotomes are used to within 1 mm of the sinus floor. *F*, Radiograph taken to verify osteotome depth. *G*, Larger osteotomes (no. 3 and 4 Summers osteotomes, 3l) are used for the final enlargement. *H*, Space is created in the bone for the graft material. *I*, An amalgam carrier is used to load the graft material. *J*, The osteotome is repositioned in the osteotomy. *K*, Upward pressure is applied to infracture the sinus floor. The graft acts as a cushion. *L*, The sinus expands according to Pascal's law.

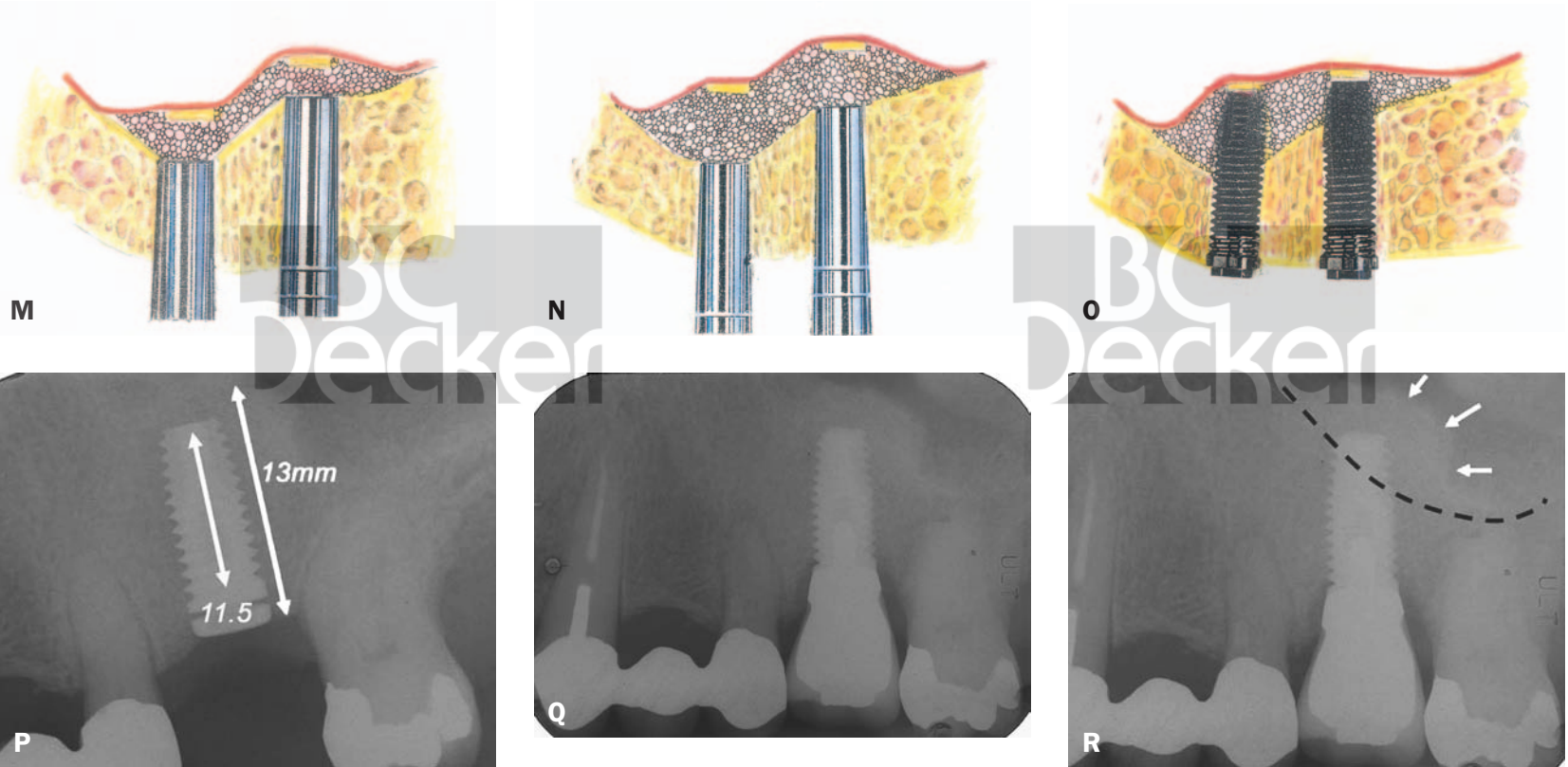


FIGURE 26-5. Continued. M and N, Additional material is added until the sinus floor is elevated to an appropriate height. O, Implants are placed at the time of surgery. P, Radiograph showing implant placement. Q and R, Final radiographs 12 months later showing the completed case. Note significant augmentation of the sinus. Compare with B and D.

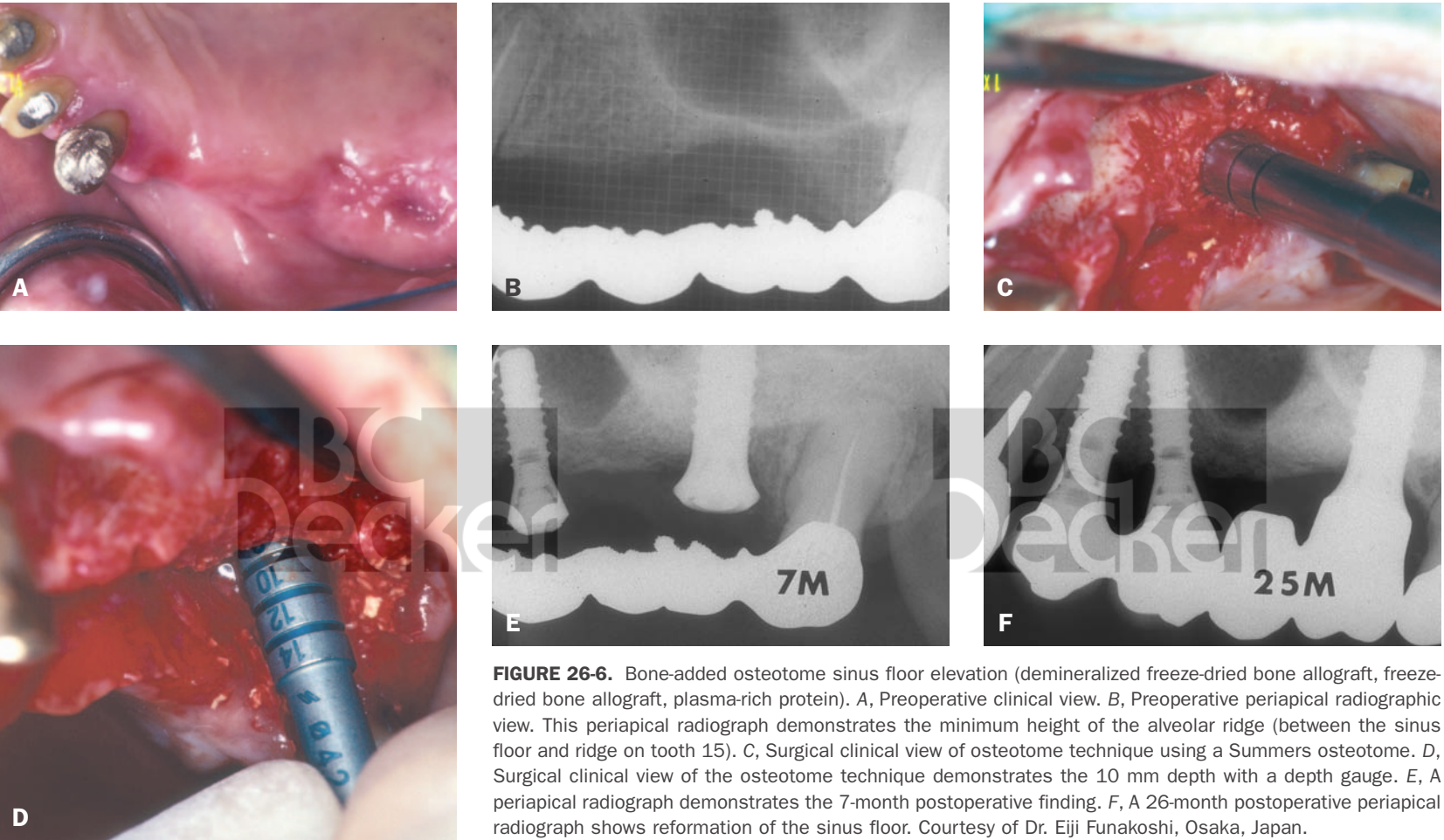


FIGURE 26-6. Bone-added osteotome sinus floor elevation (demineralized freeze-dried bone allograft, freeze-dried bone allograft, plasma-rich protein). A, Preoperative clinical view. B, Preoperative periapical radiographic view. This periapical radiograph demonstrates the minimum height of the alveolar ridge (between the sinus floor and ridge on tooth 15). C, Surgical clinical view of osteotome technique using a Summers osteotome. D, Surgical clinical view of the osteotome technique demonstrates the 10 mm depth with a depth gauge. E, A periapical radiograph demonstrates the 7-month postoperative finding. F, A 26-month postoperative periapical radiograph shows reformation of the sinus floor. Courtesy of Dr. Eiji Funakoshi, Osaka, Japan.

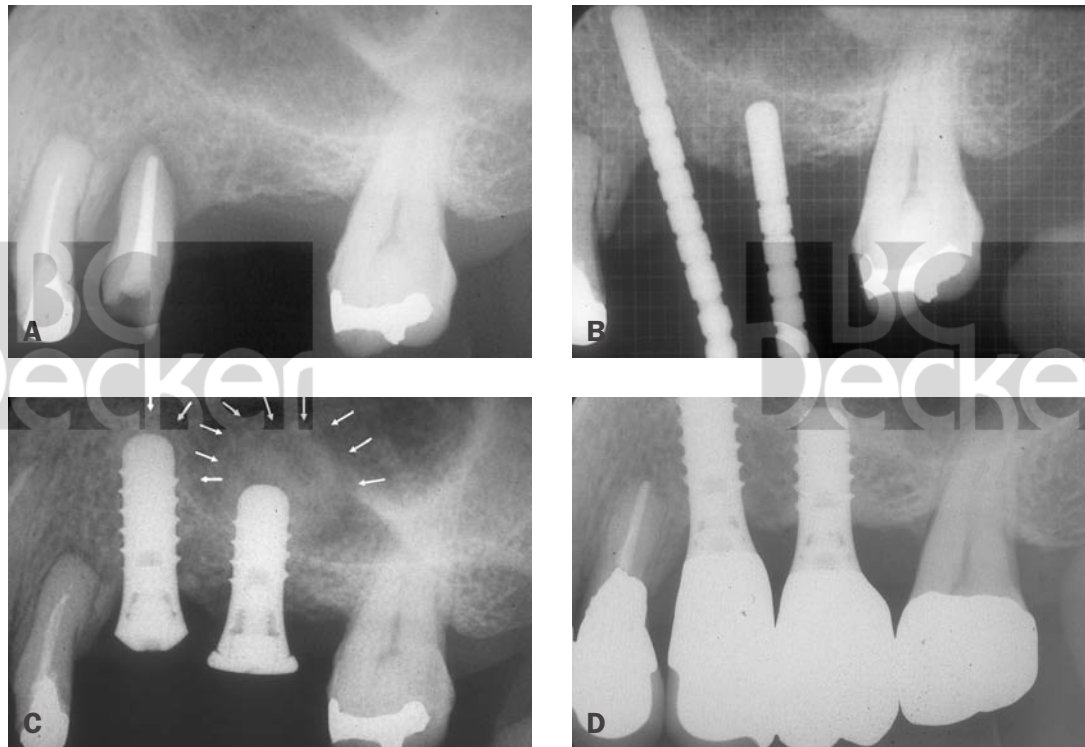


FIGURE 26-7. Bone-added osteotome sinus floor elevation (demineralized freeze-dried bone allograft, freeze-dried bone allograft, PRP). A, Preoperative periapical radiograph shows the minimum height of the alveolar ridge (between the sinus floor and ridge on tooth 15). B, Surgical periapical radiograph demonstrates the actual height (5 mm) of the alveolar ridge with a depth gauge. C, A surgical periapical radiograph demonstrates completion of the sinus lift. D, A 2-year postoperative periapical radiograph finding shows reformation of the sinus floor. Courtesy of Dr. Eiji Funakoshi, Osaka, Japan.

Procedure.

1. The available bone below the sinus has been carefully evaluated.
2. The procedure is begun with a no. 5 or FS (Summers) osteotome. The osteotome is “lightly” malleted in an attempt to displace the crestal bone apically.

Note: If the crestal bone does not displace immediately, a calibrated 6 mm-diameter bone trephine bur is used. Fugazzato (2002, 2003) recommended the use of a 3 mm trephine bur for this procedure. The trephine (3–6 mm) is often the instrument of choice.

3. The trephine bur is used to create a cut in the bone just below the sinus floor.

4. Gentle pushing or malleting on the FS osteotome will move the plug inward.

Note: Once freed, the plug will freely move up and down with light, gentle pressure. If necessary, membrane integrity can be checked at this time using the Valsalva technique (see MOAT technique).

5. The prepared graft material is loaded into the osteotomy and an appropriately sized osteotome is used with gentle pushing or malleting to move the graft apically.

Note: Remember, at no time does the osteotome enter the sinus cavity.

6. The gentle pressure of the graft material and fluids will facilitate broad dissection of the schneiderian membrane.
7. Once the core and several loads of graft material have been added to provide for a future implant site, the area is closed and allowed to heal. Membrane placement prior to closure, although optional, is recommended.

Note: The combination of the “bone core” and “graft material” should permit a sinus elevation of approximately 5 to 8 mm.

8. At the time of future implant placement, the osteotome technique may again be used if additional implant length is still required.

Clinical examples of this procedure are shown in Figures 26-8 and 26-9.

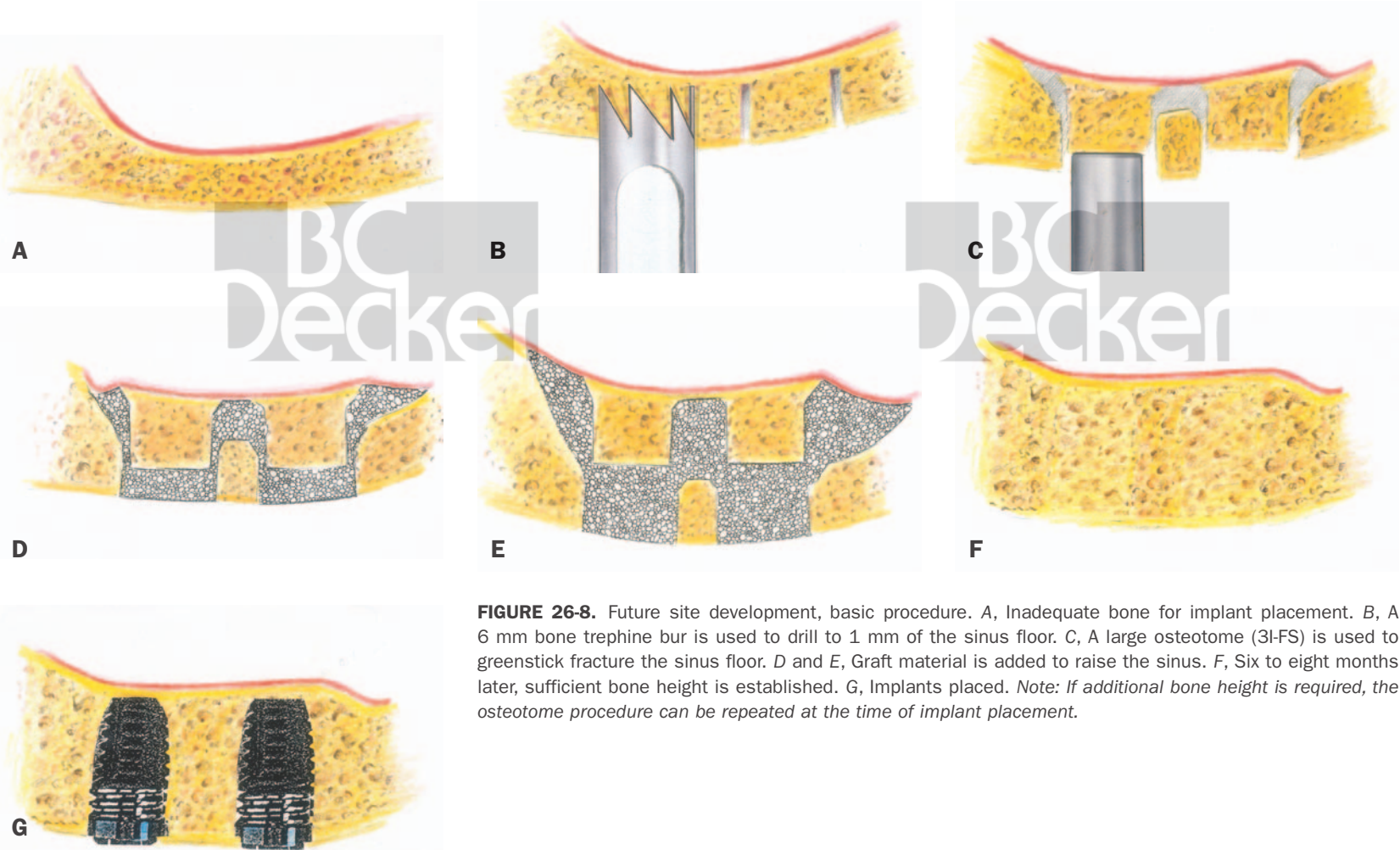


FIGURE 26-8. Future site development, basic procedure. A, Inadequate bone for implant placement. B, A 6 mm bone trephine bur is used to drill to 1 mm of the sinus floor. C, A large osteotome (3I-FS) is used to greenstick fracture the sinus floor. D and E, Graft material is added to raise the sinus. F, Six to eight months later, sufficient bone height is established. G, Implants placed. *Note: If additional bone height is required, the osteotome procedure can be repeated at the time of implant placement.*

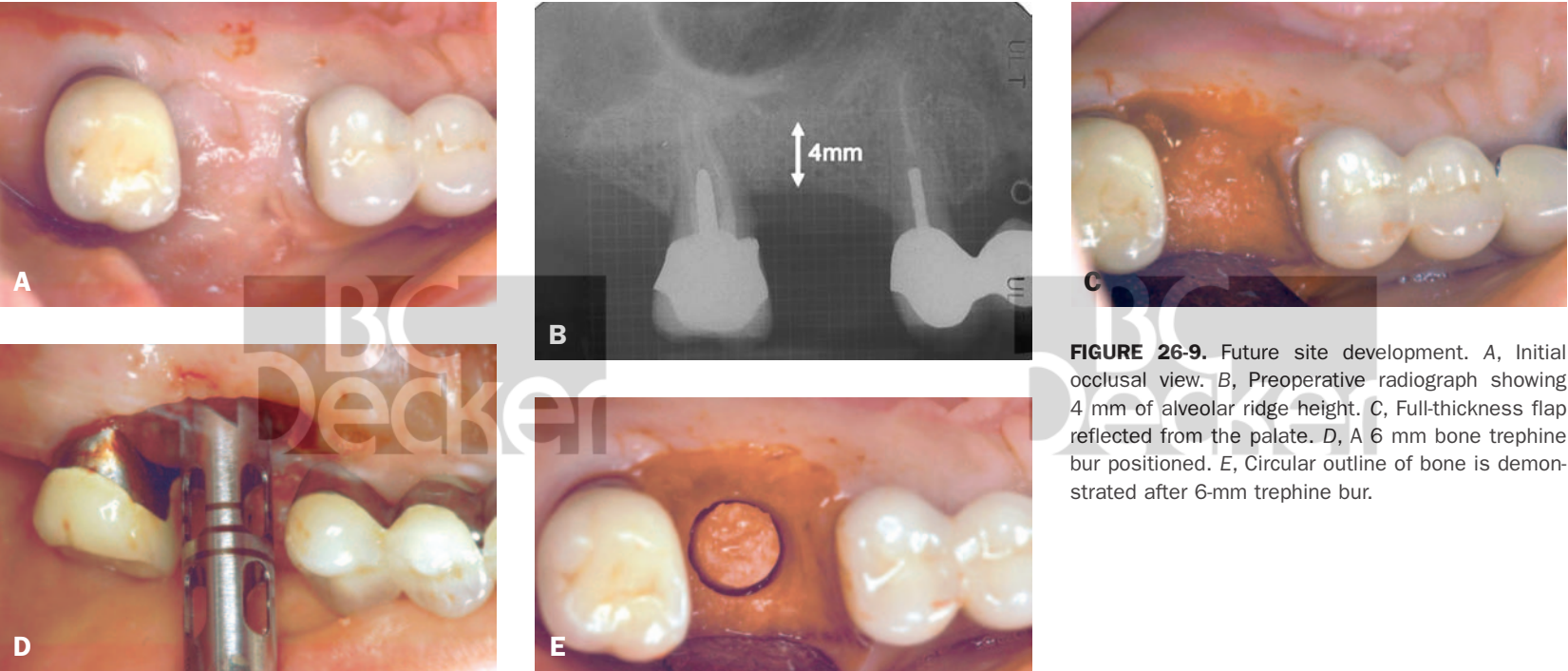


FIGURE 26-9. Future site development. A, Initial occlusal view. B, Preoperative radiograph showing 4 mm of alveolar ridge height. C, Full-thickness flap reflected from the palate. D, A 6 mm bone trephine bur positioned. E, Circular outline of bone is demonstrated after 6-mm trephine bur.

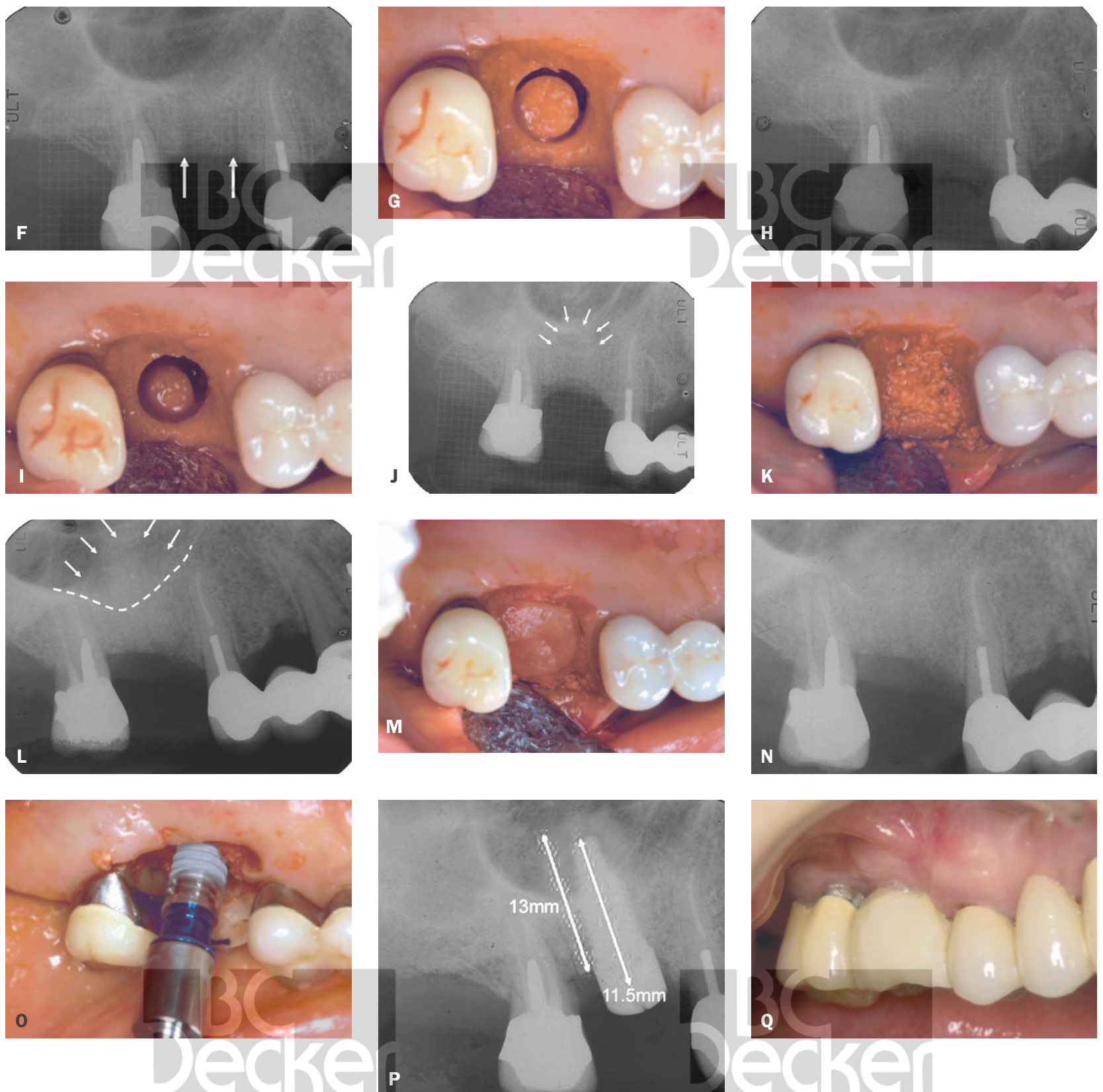


FIGURE 26-9. *Continued.* F, Radiograph showing vertical bone cuts. G, Initial infrafracture of the bone core. H, Radiograph of the initial infrafracture of a bony plug. I, The bone core completely freed and the sinus floor elevated. J, Radiograph showing complete infrafracture of the bony core. K, Graft material added to the defect. L, Radiograph of the grafted sinus. M, Flap reposition prior to suturing. N, Radiograph 8 months later. Note increased bone height. O, Implant placed (11.5 × 5 mm Osteotite, 3I). P, Radiograph of the implant with healing abutment. Q, Implant temporized for 3 months for progressive loading.



Sinus Elevation Surgery

Tooth loss in the posterior maxilla is so common that more than 20% of the adult population (over 18 years) is partially or fully edentulous in at least one quadrant (Figure 27-1). Figures 27-1 and 27-2 show the normal sinus and the changes that occur with loss of the maxillary teeth. Implant restoration of this area is often complicated by

1. Decreased bone density (types III and IV bone) (Jaffin and Berman, 1991)
2. Increased occlusal forces (Zimmer and Small, 1999)
3. Inadequate bone height (Smiler and colleagues, 1992)
 - a. Pneumatization of the sinus
 - b. Bone resorption toward the palate
4. Decreased interarch space (Tatum, 1986, 1989)
5. Early tooth loss (Watzel and colleagues, 1998)
6. Prosthetic cantilevering of the buccal cusps (Rangert and colleagues, 1997, 1998)

Successful posterior maxillary implant restoration is predicated on achieving implant stability (Fugazzatto and Vlassis, 1998; Jensen and colleagues, 1998; Khoury, 1999; Fugazzatto, 2003). This often requires sinus grafting for vertical bone augmentation. Tatum (1977, 1986) introduced sinus grafting, and Boyne and James

(1980) pioneered the modern lateral wall sub-antral augmentation. The procedure has changed little, although the nature and quality of the implant materials have undergone a good deal of variability (see Figure 27-2).

Anatomy

The maxillary sinus has been described as a “quadrangular,” pyramidally shaped cavity (Chanavaz, 1990), the base of which is the lateral nasal wall and the apex of which is the zygomatic arch. It is the largest of the paranasal sinuses and in the area of the molars has an average length \times width \times height of 38 \times 33 \times 38 mm (Schaffer, 1920).

The sinus is lined by a pseudostratified ciliated columnar or cuboidal epithelium known as the schneiderian membrane. Goblet cells and glands are present that provide mucus. There is a thin endosteal basement membrane with a few osteoblasts, which may account for sinus expansion with the loss of teeth (Chanavaz, 1990).

There are few elastic fibers, which helps facilitate membrane reflection (Misch, 1999).

Anterior Wall

The anterior wall is composed of compact bone through which the nerves and blood vessels to the teeth run. It is thin anteriorly (cuspid area) and thickens posteriorly, where it unites with the zygomatic process. The facial and infraorbital arteries and nerves run on the outer surface. The thickness of bone is variable depending on the length of edentulism (Ulm and colleagues, 1995) and antral pneumatization (Tallgren, 1972).

Posterior Wall

This is the tuberosity area, and it separates the sinus from the pterygomaxillary fissure. *The internal maxillary artery and pterygoid plexus rest in the distal periosteum. This area should be avoided during surgery.*

Superior Wall

The superior wall is the orbital floor. The bone is thin and brittle, especially with the suborbital groove running through it (Chanavaz, 1990). Dehiscences are often present, making the schneiderian membrane the only thing preventing contact with the eye. *This area should be avoided during surgery.*

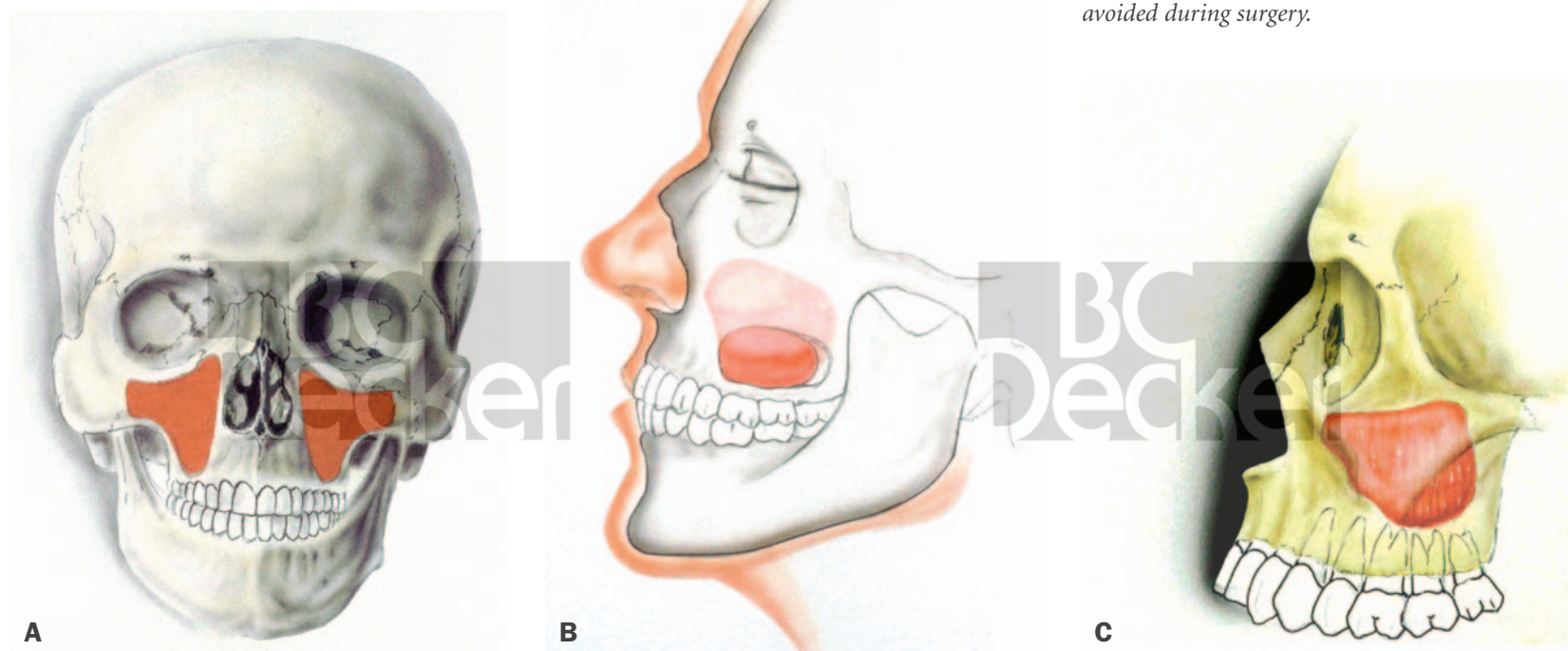


FIGURE 27-1. Sinus location. A, Anatomic facial view of the maxillary sinus. B, Lateral view of the sinus window. C, Normal sinus position.

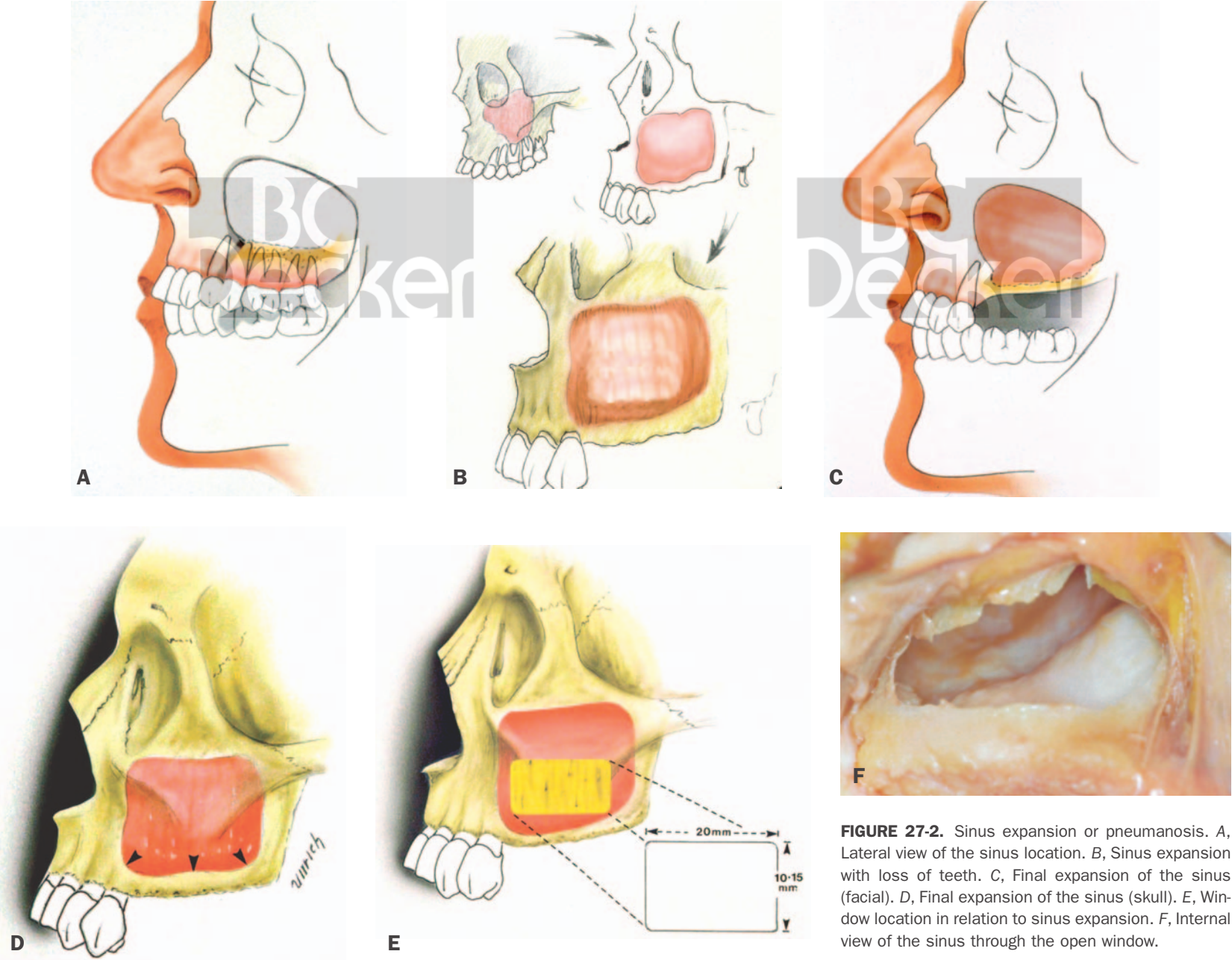


FIGURE 27-2. Sinus expansion or pneumanosis. A, Lateral view of the sinus location. B, Sinus expansion with loss of teeth. C, Final expansion of the sinus (facial). D, Final expansion of the sinus (skull). E, Window location in relation to sinus expansion. F, Internal view of the sinus through the open window.

Medial Wall

This bony wall separates the sinus from the nasal cavity. The nasal side has the inferior and middle conclave, which divides it into thirds. The superior side of the medial wall has the maxillary osteum and perpendicular lamina, which permits sinus drainage into the middle conchae area. Surgery is limited to the inferior conchae area. When thickened membranes, cysts, or mucocèles are present, care must be taken not to close off the osteum.

Antral Floor

The antral floor is composed of the maxillary alveolar process and hard palate. It is thinnest in the molar area, where it is most subject to exposure with extraction. The floor expands with age

and can be very thin or nonexistent, especially in the area of the alveolar ridge (Schaeffer, 1910).

Septae

Chavanez (1990) described the sinus septal structures as being similar to the floor plates in a ship stretching from the outer to the inner walls, creating chambers and buttresses separated by septae and spines. Underwood (1910) described three types of septae:

1. Resulting from three different periods of tooth development and dividing the sinus into three areas:
 - a. Premolar
 - b. First and second molars
 - c. Third molar

2. Dental septae, which develop between approximating teeth owing to the sinus sinking between the roots of the teeth
3. Small, irregularly shaped and positioned septae, which may carry blood vessels and nerves

Tooth loss results in bone loss owing to

1. Resorption of the alveolus
2. Pneumatization of the sinus into the socket owing to the osteoclastic activity of the membrane

This combination produces a thinning of the alveolus, with irregular valleys and septae, which sometimes complicate membrane reflection owing to a combination of

1. Thinning of the sinus membrane over the septae and spines

2. The membrane being firmly bound down in these areas, making reflection more difficult and increasing the risk of tearing (Chanavez, 1990)

Underwood (1910) found 66% (30 of 45 skulls) with septae of between 6.5 and 13 mm, which occurred more on the left side than on the right side (3:1). Ulm and colleagues (1995) found the rate of occurrence to be 31.7% (13 of 41 skulls), with a mean height of 7.9 mm.

Kim and colleagues (2006) using reformat-
ted CT images on 100 patients (200 sinuses)
found one or more septae in 26% (53/200).
The number varied with the location: 25.4%
(anterior), 50.8% (middle); and 23.7%
(posterior).

*Most septae are located between the second
premolar and the first molar.*

Note: Fortunately, most septae are small and
can be avoided by making the inferior osteotomy
3 to 4 mm above the sinus floor. Some septae
may be large enough to partially or completely
wall off an area of the sinus, complicating the
surgery. A careful review of the computed
tomographic (CT) scan will show the septa
and permit surgical modification as required
(Figure 27-3).

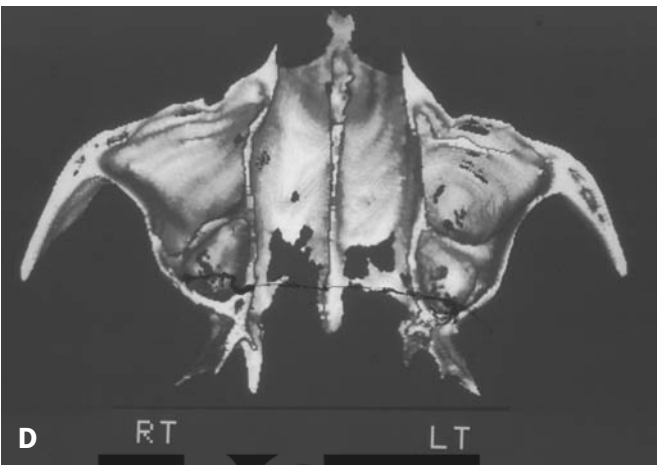
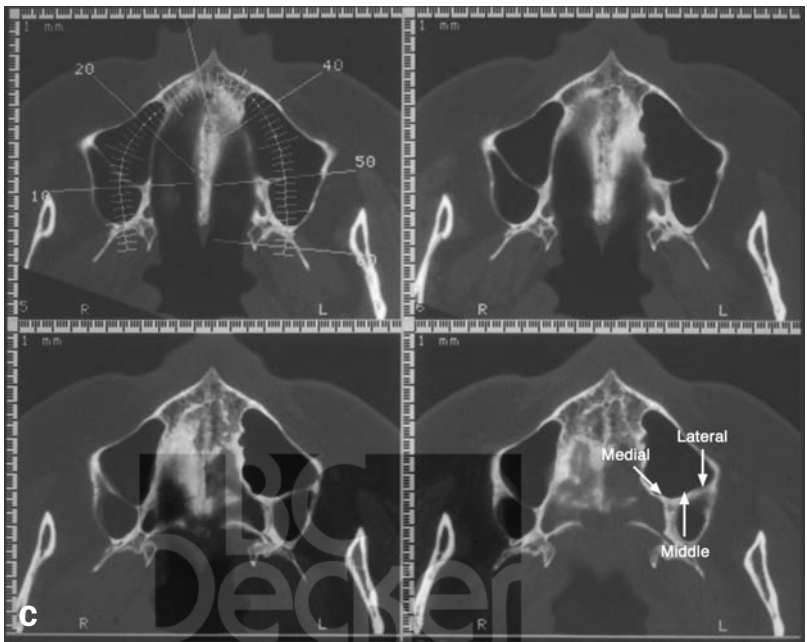
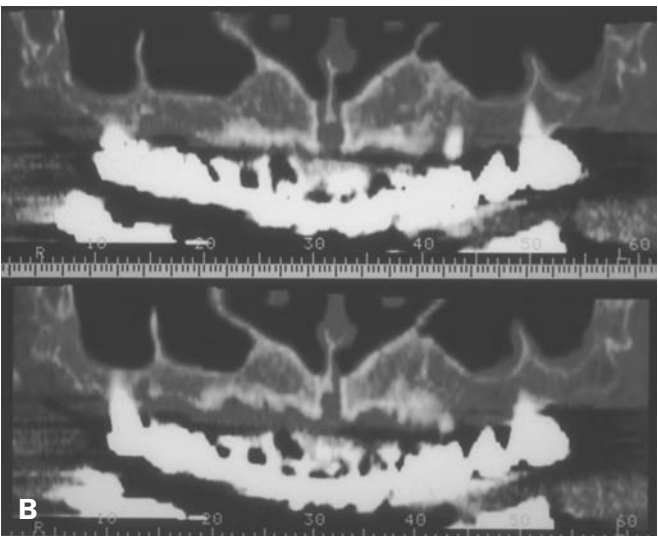
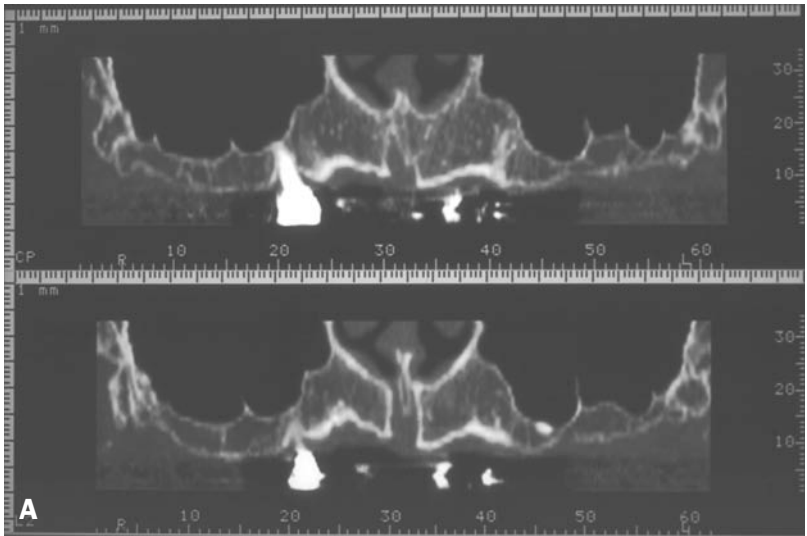


FIGURE 27-3. Sinus septae. A, Note small septae in both the right and left sinuses. B to D, Different computed tomographic scan views (panorex, occlusal, and reformatted images) of the same septae that partially and completely run through the sinus. Note the details and differences of the views.

Vascular Supply for the Sinus

Arterial

- 1. Conchae medial arteries and osteal artery
- 2. Internal maxillary artery
- 3. Alveolar artery
- 4. Suborbital, ethmoidal, facial, and palatal arteries

Venous

- 1. Sphenopalatine vein
- 2. Pterygomaxillary plexus

Innervation

- 1. Trigeminal
- 2. Dental
- 3. Suborbital

Indications for Sinus Lift

Inadequate vertical bone height (< 5 mm) for implant placement owing to

- 1. Pneumatization of the sinus
- 2. Resorption of the alveolar ridge
- 3. A combination of both

Contraindications

- 1. Sinus pathology
 - a. Cysts
 - b. Mucocoeles
 - c. Tumors

- 2. Acute, chronic, or allergic sinusitis
- 3. Noncompliant patient
- 4. Smoking or alcoholism
- 5. Systemically compromised patient
- 6. Uncontrolled diabetes
- 7. Pregnancy
- 8. Maxillary radiation
- 9. Nasal steroids
- 10. Cocaine dependency
- 11. Oral antral fistula
- 12. Odontogenic infections
- 13. Sepsis
- 14. Severe medical fragility
- 15. Interarch distance > 2:1

Patient Evaluation

I. Clinical

Owing to the palatal resorption of bone, careful preoperative prosthetic evaluation is required. The clinician should have a set of study models, a bite registration, and, ideally, a face bow transfer for accurate mounting. A diagnostic workup is used to help determine

- 1. Final tooth position
- 2. Crown-to-root (implant) ratio. If a > 2:1 ratio exists, then the case should not be treated by sinus augmentation alone.
- 3. Occlusal function. Ideally, a cuspid-protected occlusion is best.
- 4. Occlusal design to determine the position of the buccal cusps (normal occlusal position or crossbite).

- 5. Interarch space. A minimum of 5 to 7 mm is required for prosthetic restoration. If the distance is inadequate, it will have to be created by the following (Misch, 1987):
 - a. Alteration of the mandibular occlusal plane
 - b. Vertical osteotomy of the maxillary alveolus
 - c. Gingivectomy for removal of bulky tissue
- 6. Periodontal disease. Periodontal disease causes pathologic changes, resulting in thickening of the maxillary sinus mucosa (Engstrom and colleagues, 1988; Moskow, 1992) owing to close root proximity of the sinus and maxillary roots (Eberhardt and colleagues, 1992) and a significantly greater ($p > .50$) degree of implant failure, which is not affected by immediate or delayed placement (Evian and colleagues, 2004).

Beaumont and colleagues (2005) recently found that 41% of patients who had chronic periodontitis and a history of symptoms had sinus disease. They concluded that the study reinforces the importance of history taking and thorough clinical and radiographic evaluations prior to performing sinus augmentation (Figure 27-4).

II. Radiographic Analysis

A. Panorex Radiograph. The panorex radiograph, although providing a gross overview of the sinus, may have up to 20 to 25% distortion error and may distort or miss some or all of the following (Fredholm and colleagues, 1993):

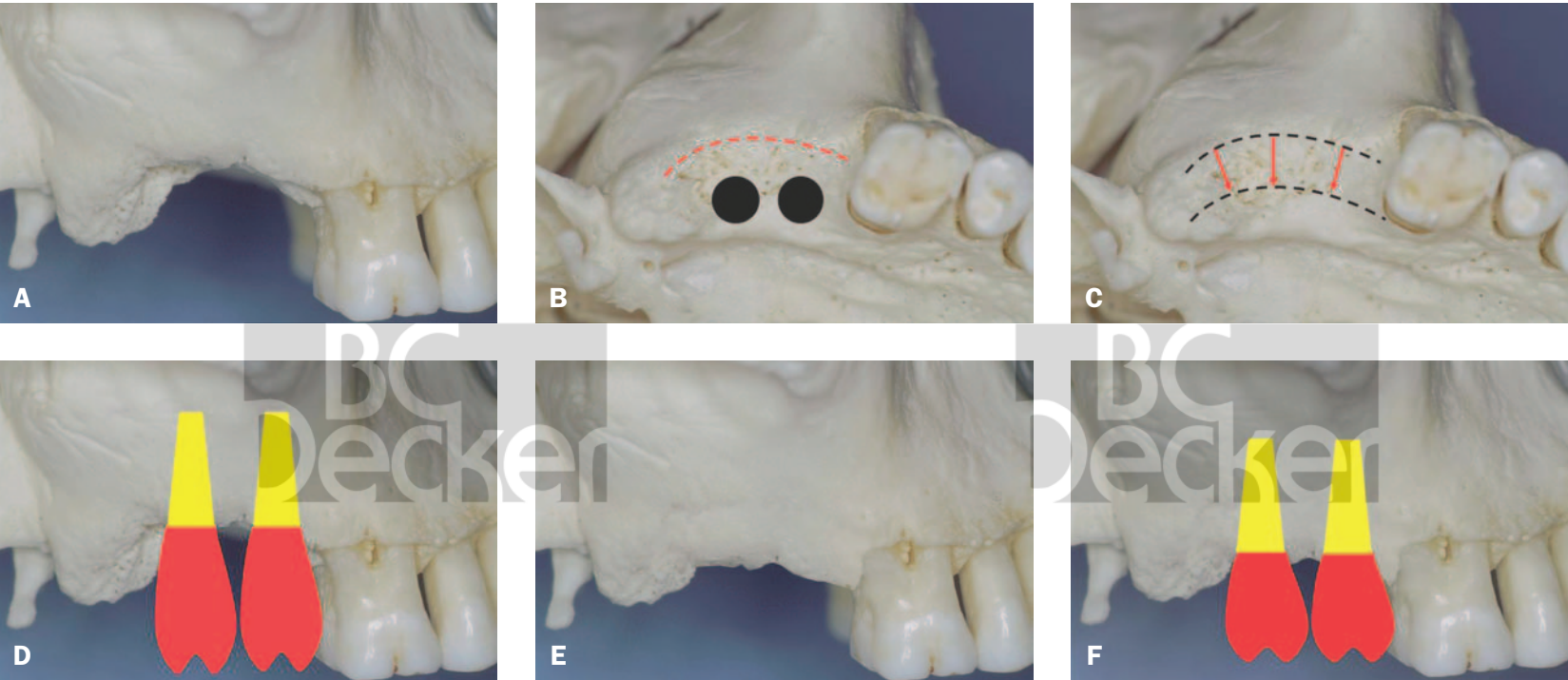


FIGURE 27-4. Prosthetic considerations. A, Severe ridge resorption. B, Anticipated unfavorable crown-to-root ratio ($\geq 1:1$). C, Palatal resorption of the ridge. D, Anticipated palatal position of the implants—crossbite relationship. E, Ridge augmentation to alter the crown-to-root ratio. F, Favorable crown-to-root ratio.

1. Bone between the sinus floor and the crest of the ridge
2. Bone septa
3. Sinus compartments
4. Size of the sinus
5. Pathology

The panorex radiograph lacks the clarity and diagnostic reliability required for presurgical

analysis by the less experienced surgeon. It is therefore strongly recommended that the panorex radiograph not be used for surgical analysis.

B. Reformatted CT or CT Scan. For proper presurgical diagnosis and evaluation, this procedure is recommended for all sinus lift cases (Rothman and colleagues, 1988; Solar et al. 1992; Ulm and colleagues, 1995). The CT scan will

provide the following information (Figures 27-5 and 27-6).

Note: A radiographic surgical stent is often helpful for establishing implant-ridge relationships in extensive prosthetic and edentulous cases.

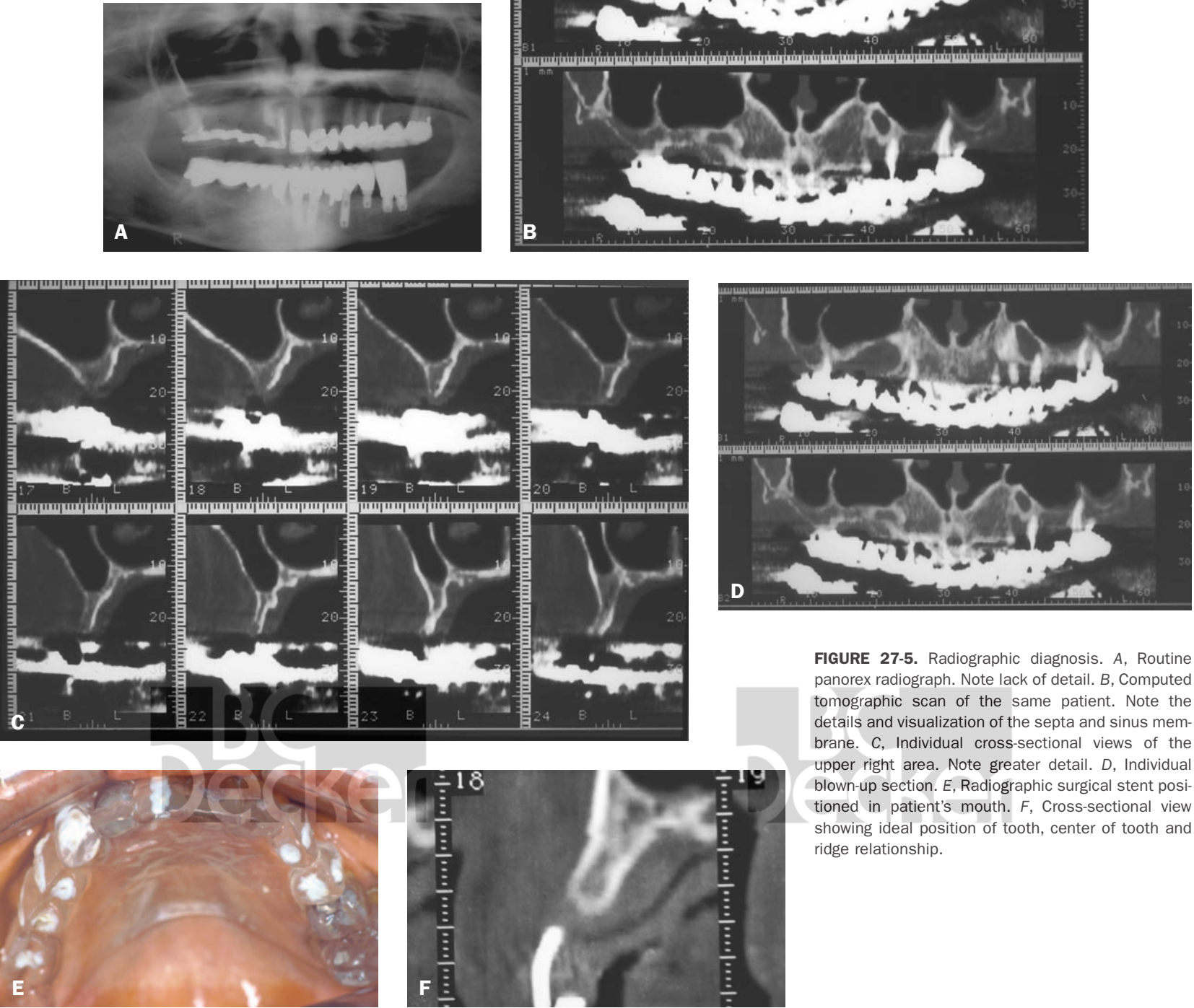


FIGURE 27-5. Radiographic diagnosis. A, Routine panorex radiograph. Note lack of detail. B, Computed tomographic scan of the same patient. Note the details and visualization of the septa and sinus membrane. C, Individual cross-sectional views of the upper right area. Note greater detail. D, Individual blown-up section. E, Radiographic surgical stent positioned in patient's mouth. F, Cross-sectional view showing ideal position of tooth, center of tooth and ridge relationship.

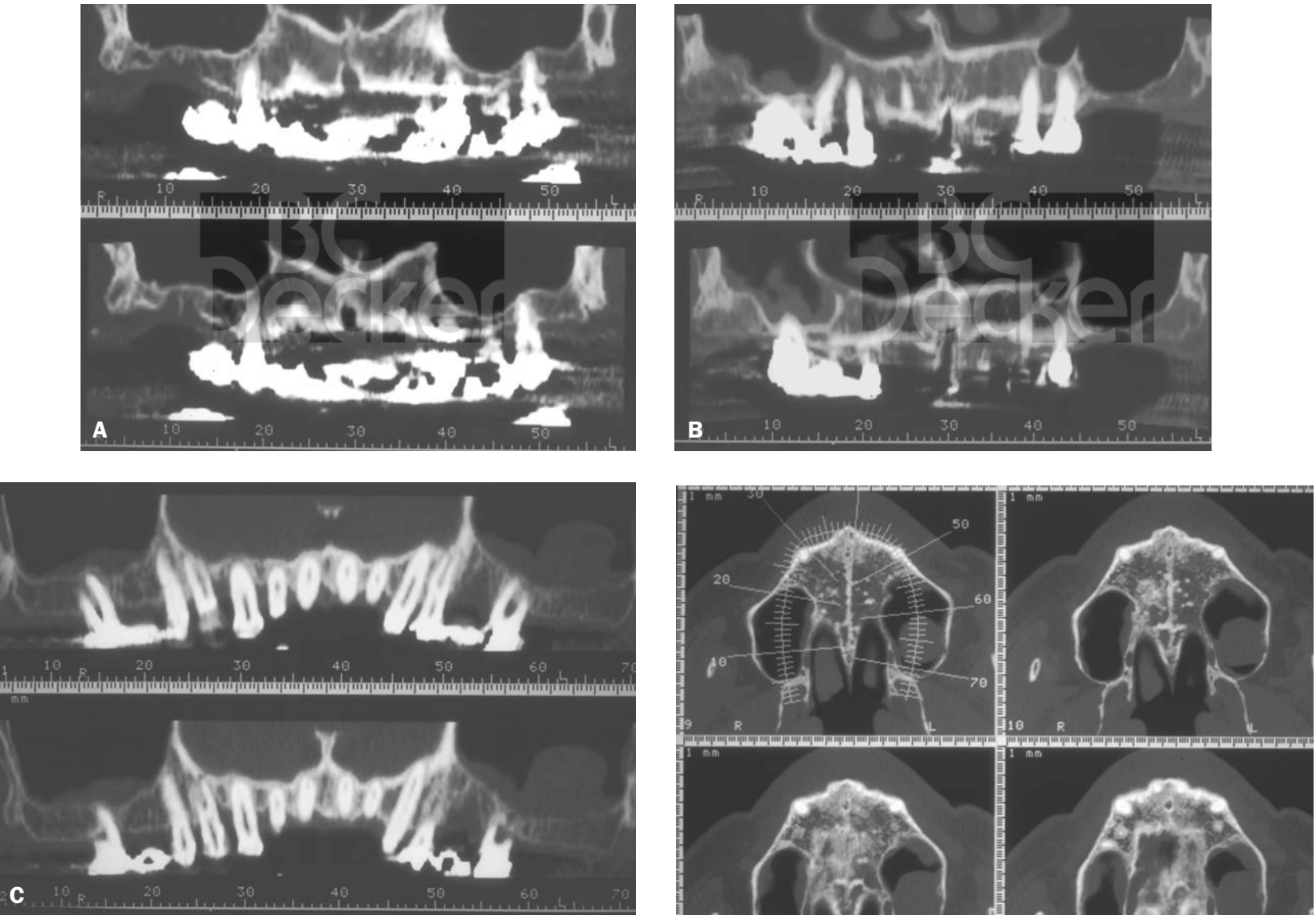


FIGURE 27-6. Sinus pathology. *A*, Normal sinus. *B*, Sinus with a thickened membrane. *C*, Thickened membrane on the left side and a mucocoele or cyst on the right side. *D*, Cross-sectional view showing the mucocoele completely filling the sinus.

1. Anatomy
 - a. Sinus
 - b. Surrounding structures
2. Septae
 - a. Length
 - b. Height
 - c. Location
3. Pathology
 - a. Tumors
 - b. Mucocoeles
 - c. Retention cysts
 - d. Membrane thickening
 - e. Combinations
4. Membrane quality
 - a. Thin (healthy)
 - b. Thickened (smokers, previous sinus infections)
5. Residual ridge
 - a. Height

- b. Width
6. Thickness of the lateral wall
7. Accurate subantral classification (Misch, 1984)
8. Size of the sinus (estimated volume)
9. Diagnostic views of the
 - a. Anterior ethmoid sinus
 - b. Anterior ethmoid–middle meatal complex

Implant Placement

I. Staged or Delayed Implant Placement

Subantral Classification. The Misch (1984, 1987) classification is based on the residual bone height between the antral floor and the edentulous ridge crest, which is used for determining treatment (Figure 27-7). It is further subdivided into two divisions.

1. Division A: The crestal bone width is ≥ 5 mm. No treatment is necessary (Table 27-1).
2. Division B: The crestal bone width is 2.5 to 5 mm. Division B requires either additional horizontal or vertical ridge augmentation or a combination thereof.

Note: Ulm and colleagues (1995) stated that the “limiting factor for endosseous implant placement in the posterior maxilla is not the width but the height of the alveolar ridge.”

Misch (1999) noted that he has not placed implants (SA-3 and SA-4; see Table 27-1) simultaneously with lateral sinus augmentation since 1993 and recommended delaying treatment for the following reasons:

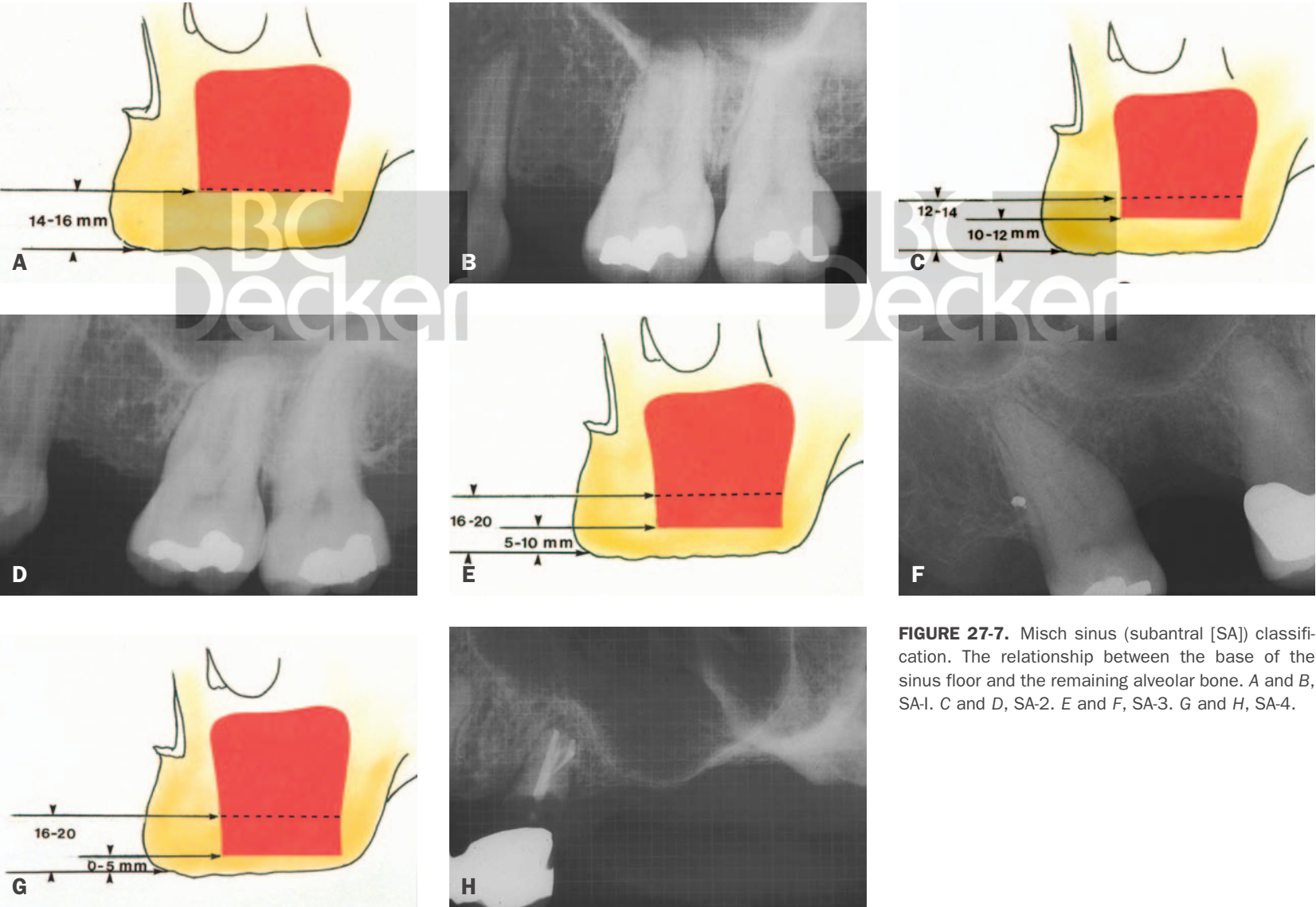


FIGURE 27-7. Misch sinus (subantral [SA]) classification. The relationship between the base of the sinus floor and the remaining alveolar bone. A and B, SA-1. C and D, SA-2. E and F, SA-3. G and H, SA-4.

Table 27-1 Subantral Options for Division A		
SA-1	Vertical bone height ≥ 12 mm	Conventional implant placement No sinus augmentation required
SA-2	Vertical bone height of 10–12 mm	Sinus lift (osteotome technique) with osteotomes 1. Sinus floor elevation of 2–4 mm 2. Immediate implant placement
SA-3	Vertical bone height of 5–10 mm	Sinus lift/staged, implant placement 1. Lateral wall sinus lift 2. Increase bone height to > 12 mm 3. Implant placed 2–4 mo later
SA-4	Vertical bone height of ≤ 5 mm	Sinus lift/delayed implant placement 1. Lateral wall sinus lift 2. Increase bone height to > 12 mm 3. Delayed implant placement of 8–12 mo
SA = subantral.		

- 1. Greater implant stability owing to apical bone graft support
- 2. Greater graft stability
- 3. Permits previous analysis of bone graft
- 4. Permits secondary graft placement if voids are found
- 5. Accurate assessment of vertical bone augmentation height, preventing secondary sinus perforation
- 6. Prevents implant loss owing to infection
- 7. Greater difficulty when treating infections with simultaneous placement

Note: Most clinicians advocate the simultaneous placement of implants if there is ≥ 5 mm of residual bone height present and initial implant stability is achievable.

II. Simultaneous Implant Placement

There are no significant differences in the success rates and/or rate of infection between simultaneous or staged implant placement (Sinus Consensus Conference, 1996; Del Fabbro and colleagues, 2004; Wallace and Froum, 2004). Simultaneous implant placement has the following advantages:

- 1. Fewer surgical procedures
- 2. Less healing time
- 3. Less morbidity
- 4. Less financial expense
- 5. Less patient anxiety

Vertical Ridge Height Classification. The recommendations in Table 27-2 are based on a compilation of the most current information and are classified by the remaining bone or vertical ridge height over the sinus floor.

Note: Recent studies by Peleg and colleagues (1998) and Winter and colleagues (2002) showed that it is possible to perform a single-stage implant with a crestal bone height of as little as 1 mm.

Note: The new rough-surface implants provide greater surface area, greater retention, greater bone-to-implant contact, faster integration than similar smooth-surface implants, permitting shorter implants to be used, and greater predictability (Del Fabbro and colleagues, 2004; Wallace and Froum, 2004).

Antibiotics

Misch (1992), in discussing the risks of sinus graft surgery, noted that maxillary sinus surgery should be considered a clean-contaminated procedure with both the risk of infection of the implants and/or the grafting materials. Prophylactic antibiotics are therefore recommended to prevent the onset of infection (Table 27-3).

Anti-Inflammatory Agents (Misch and Moore, 1989)

Dexamethasone 3 mg:

- 1. 9 mg on the morning of surgery
- 2. 6 mg on the morning after surgery (day 1)
- 3. 3 mg on the morning after (day 2) or Medrol dose pack: a declining dosage taken over 6 days

Analgesics.

Ibuprofen

400–800 mg three times daily/as needed for pain or

Acetaminophen with codeine

#3 every 6 hours/as needed for pain
codeine

Decongestants

Systemic

Oxymetazoline

(Afrin)

Pseudoephedrine

1 tablet three times daily starting 1 day prior to surgery
(Sudafed)
and for 2 days after surgery

Topical Spray

Oxymetazoline 0.05%

1 hour prior to surgery or

Phenylephrine 1%

Patients on Anticoagulant Therapy

All patients should be requested to stop the use of any medications that increase their bleeding time

(aspirin, ibuprofen, or warfarin) 5 days prior to the surgery. Patients placed on anticoagulant therapy by their physician should check with their physician prior to stopping their medication.

Surgical Procedure

This surgical procedure is outlined in Figures 27-8 and 27-9.

I. Flap Design and Incisions

- 1. All incisions are made on the palatal aspect of the edentulous ridge to ensure the following.
 - a. A minimum of 3 to 5 mm of keratinized gingiva is maintained for closure and suture stability.
 - b. An incision line closure that does not approximate the osteotomy window.

Note: If simultaneous implant placement is being considered, all incisions should be made palatal enough to ensure complete implant coverage and primary healing.

- 2. A sharp horizontal or beveled palatal incision (see Langer modification in Ch. 7, “Palatal Flaps”) is begun at the tuberosity or hamular notch. It is brought forward 8 to 10 mm beyond the anterior wall of the antrum and projected vertical bony osteotomy incision as previously determined by CT scans and panorex radiographs.

Note: In cases in which there is significant alveolar resorption or a broad flat palate, care is taken not to damage the palatal artery.

Table 27-2 Vertical Ridge Height Classification		
VRH-1	≥ 12 mm	Immediate implant placement
VRH-2	≥ 7–10 mm	Osteotome technique Immediate implant placement
VRH-3	≥ 5 mm but ≤ 7 mm	Osteotome technique or lateral sinus augmentation Immediate implant placement (requires initial implant stability)
VRH-4	≤ 4 mm	Lateral sinus augmentation Delayed implant placement of 6–8 mos Implant placement for 6 mo
VRH= vertical ridge height. Note: VRH-3 and VRH-4 parameters will vary with the technical skills and experience of the clinician.		

Table 27-3 Prophylactic Antibiotics		
	Antibiotic* Systemic	Local
Amoxicillin 500 mg (Amoxil)	1 h prior to surgery Continue tid for 7–10 d	Mixed with graft material
Clindamycin 150 mg (Cleocin)	300 mg 1 h prior to surgery Continue with 150 mg tid for 7 d	Mixed with graft material
*Antibiotics should be bactericidal rather than bacteriostatic to reduce the number of pathogens rather than simply reduce their numbers (Montgomery, 1985; Peterson, 1990; Misch, 1992)		

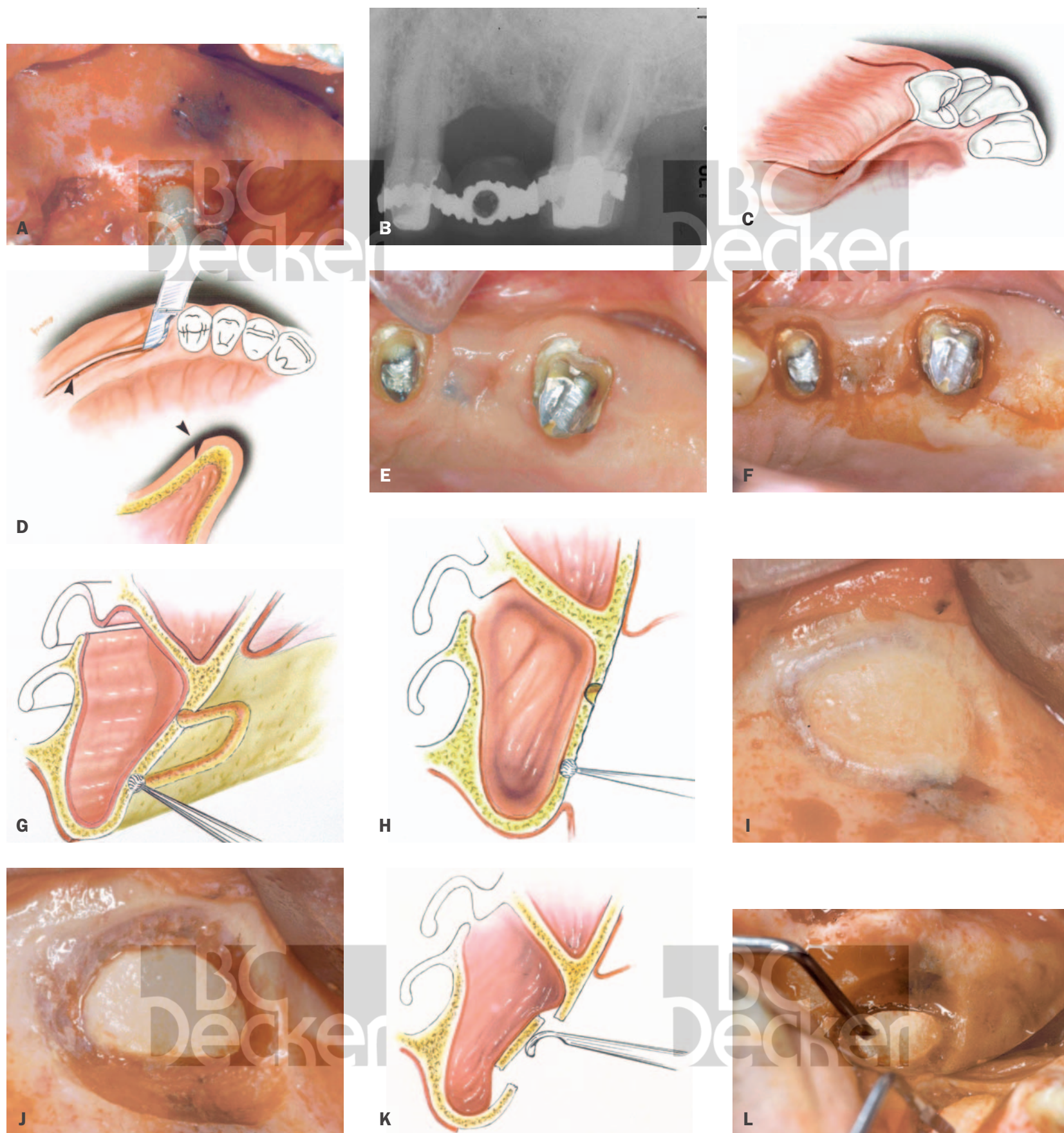


FIGURE 27-8. Basic sinus lift procedure. Note: Immediate and staged implant placements to ensure fixed temporization on a patient who is a severe gagger. A and B, Preoperative clinical and radiographic views. C and D, Diagrammatic views of the incision outline. Note palatal extension to ensure window coverage and anterior extension to ensure buccal access. E and F, Occlusal views before and after the initial incision. G and H, Window outlining with round burs, facial and lateral views. I, Initial outlining with a bur. J, Outlining almost complete. Note the bluish hue of the sinus showing through. Care must be exercised now. K and L, Gentle pressure is applied with an instrument to dislodge and infracture the window. Note the fractured edge of the clinical case.

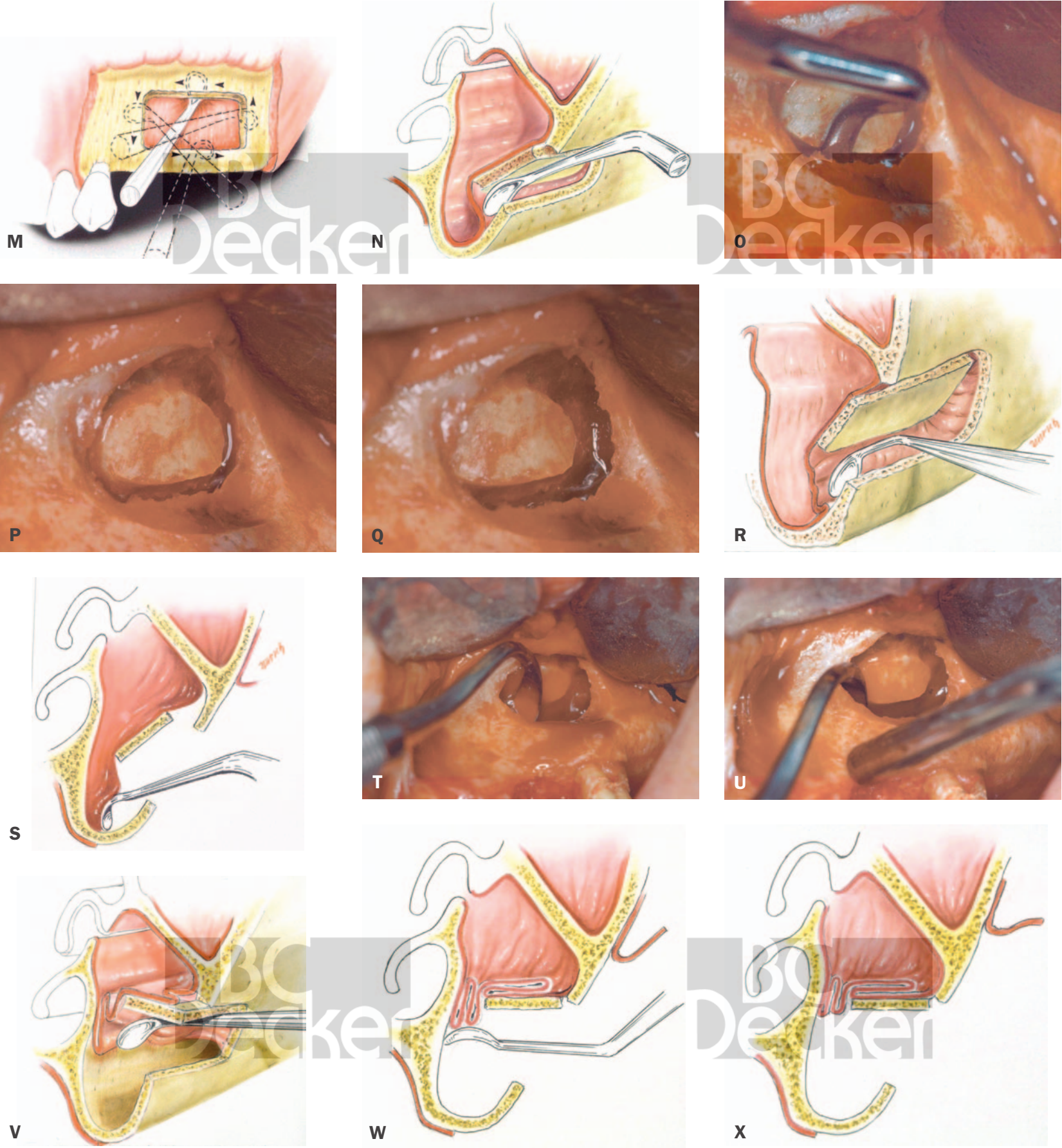


FIGURE 27-8. *Continued.* *M*, Instrument placed to initially free the membrane 360°. *N*, Cross section showing placement of the instrument. *O*, Clinical view of the instrument position to free the membrane. *P*, Expiration: window closed. Inspiration: window open and drawn in, indicating no perforations at this time. *Q*, Buccal and lateral views showing raising of the membrane on the inferior surface. *R*, Buccal and lateral views showing raising of the membrane on the inferior surface. *S* and *T*, Clinical views showing the membrane being lifted on the inferior and anterior surfaces. *U* and *V*, Facial and lateral views showing the lift extended to the medial wall. *W*, Lateral view of the completed sinus lift. *X*, Clinical view of the completed sinus lift with CollaTape on the roof.

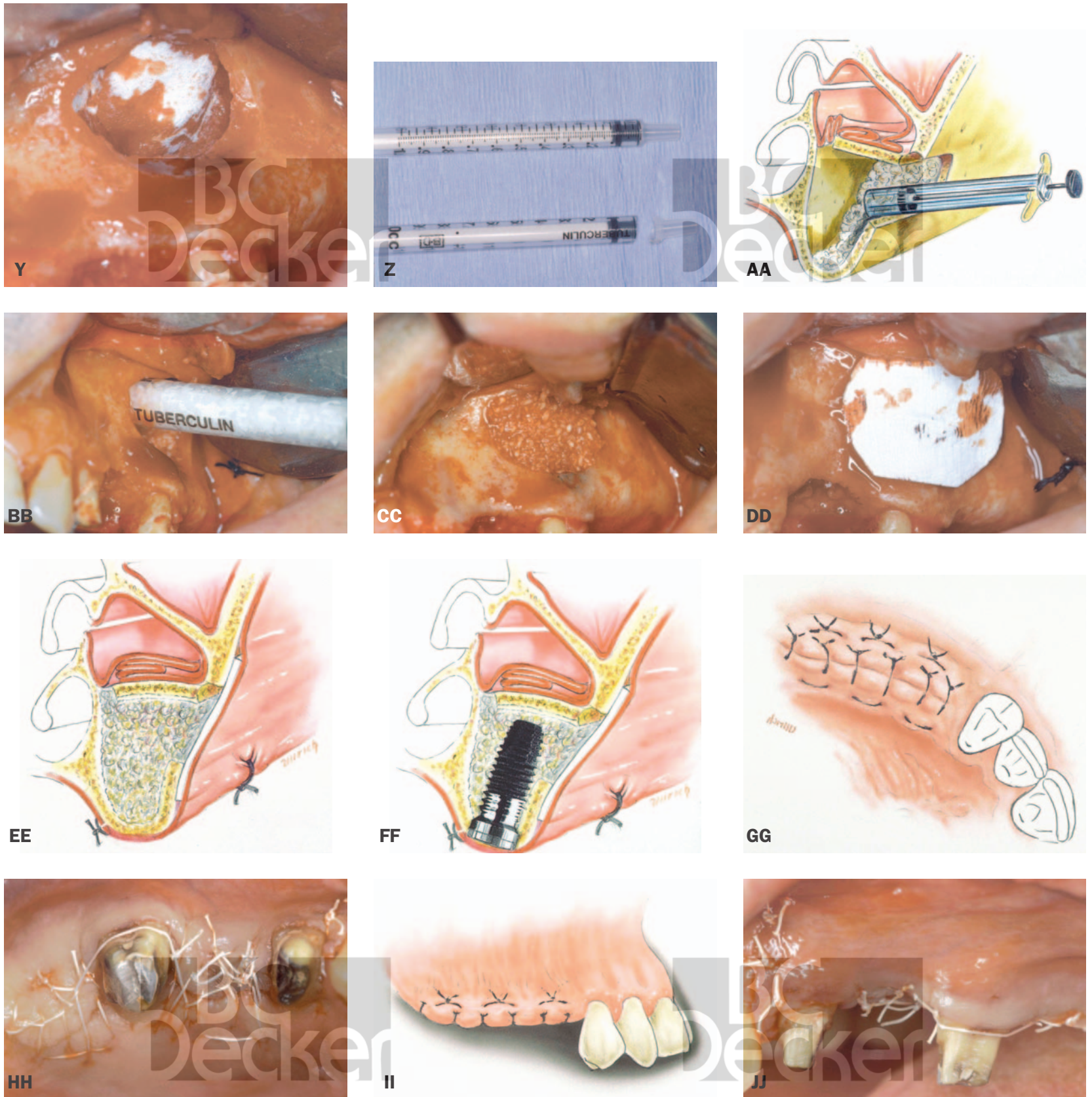


FIGURE 27-8. *Continued.* Y, Syringes prepared with the tip removed. Z, RR, Final radiograph. AA, Diagrammatic and clinical views showing the syringe positioned and graft material being inserted. Note: The anterior portion of the sinus cavity is filled first. BB, Fill completed to the window but not overfilled. CC, Resorbable membrane positioned over the window. DD, Sinus fill completed as staged or immediate. EE, Implant placement. FF, Diagrammatic and clinical occlusal views of completed suturing. GG, Diagrammatic and clinical occlusal views of completed suturing. HH and II Diagrammatic and clinical views of completed suturing. JJ, Temporary bridge is replaced.

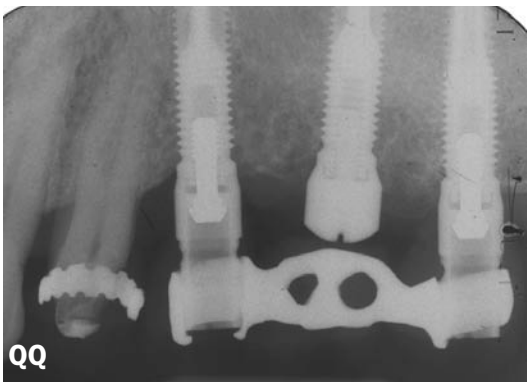
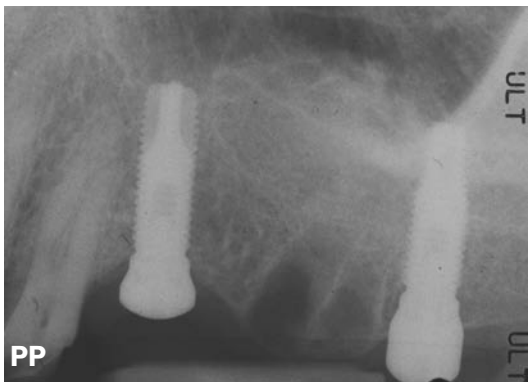
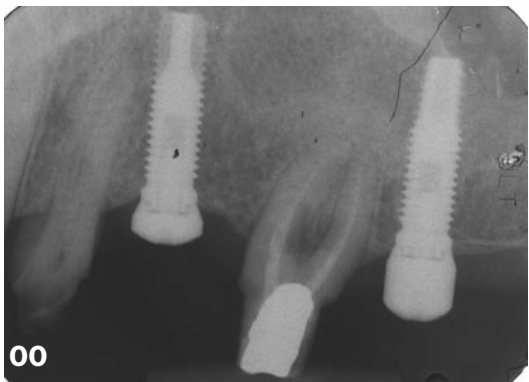
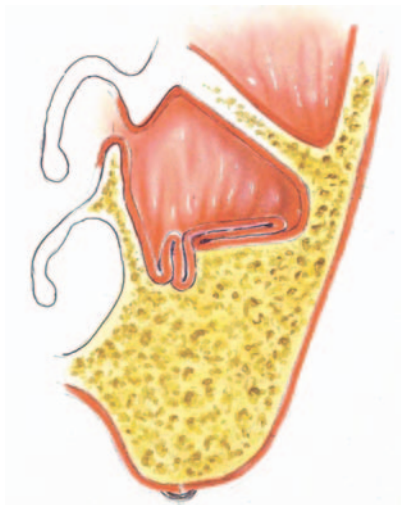
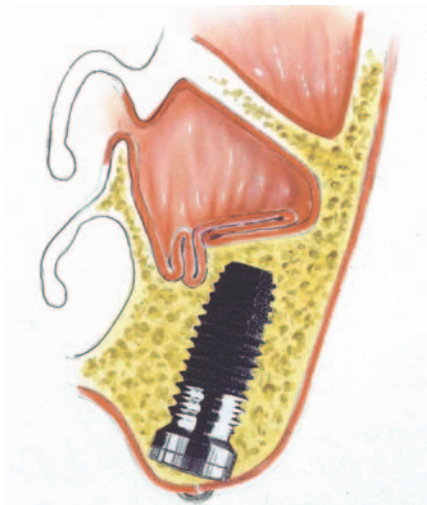
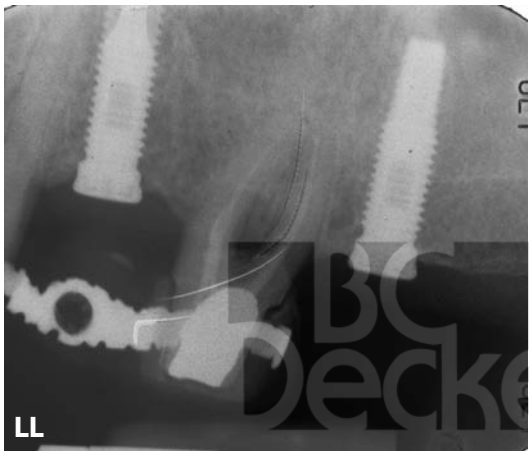


FIGURE 27-8. Continued. KK, Implants at the time of surgery. LL, Final healing with the immediate or staged procedure. MM, Final healing with the immediate or staged procedure. NN, Implants exposed 10 to 12 months later. OO, Tooth 14 extracted. Note the height of the bone in this area. Compare with B. PP, Implant temporization immediately after extraction followed by staged implant placement. QQ and RR, Final prosthetics inserted. SS, Final radiograph.



Anteriorly, if teeth are present, the incision is continued forward on their buccal aspects. It is not unusual for the incision to extend to the first premolar or canine fossa.

3. Releasing Incisions (see Figure 27-9, A to D)
- a. Anteriorly. A vertical releasing incision is made high enough into the canine fossa area of the vestibule to permit adequate flap reflection for access to the osteotomy

window. The incision is made divergent to ensure that an adequate blood supply is maintained in the flap.

- b. Posteriorly. A vertical releasing incision is made in the tuberosity to relieve flap tension.
4. Flap Reflection
Flap reflection is begun at the “apex” of the vestibular releasing incision using a

periosteal elevator or Molt curet (Smiler, 1992). A full-thickness mucoperiosteal flap is reflected in a posterior-superior direction, exposing the lateral wall of the maxilla, the canine fossa, and a portion of the zygoma. A moistened gauze positioned posteriorly under pressure will aid in flap reflection, removal of tissue tags, and hemostasis.

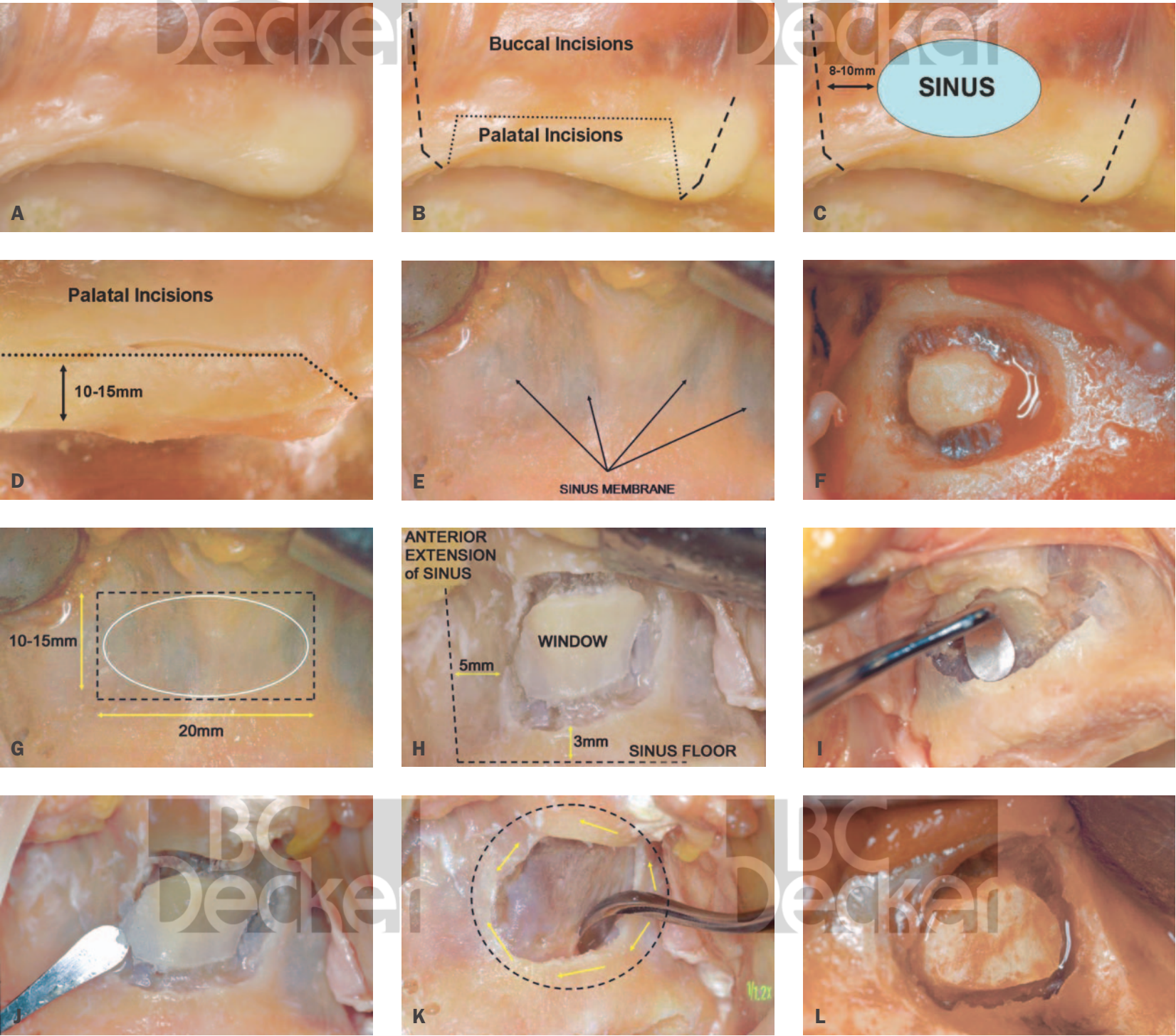


FIGURE 27-9. Basic sinus lift procedure (cadaver). *A*, Preoperative view. *B*, Buccal and palatal incisions outlined. *C*, Preoperative view showing the sinus position in relation to incisions. Note that all incisions should be at least 10 mm from sinus window. *D*, Palatal incision. Note palatal placement to ensure primary coverage. *E* and *F* as window is outlined. Note the blue or black hue of the sinus through bone. *G*, Anticipated rectangular or oval-shaped window. *H*, Bony window in relation to the sinus cavity. Note the small perforation. *I*, Blue or black hue of sinus visible through thin bone. *J*, Bony window used as roof of the sinus for support. *K*, Bony window removed for increased visualization. *L*, Initial 360° sinus elevation.

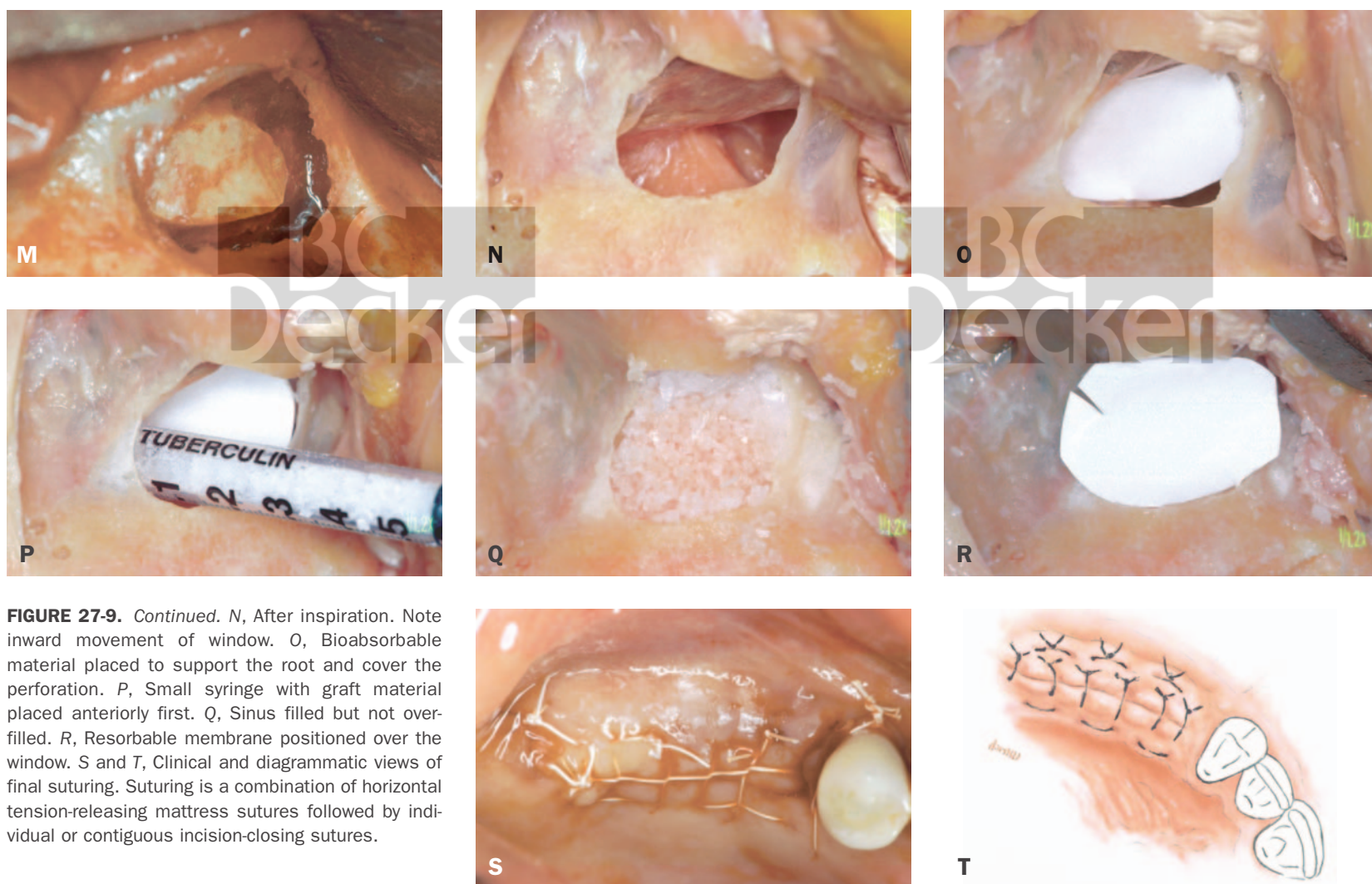


FIGURE 27-9. Continued. N, After inspiration. Note inward movement of window. O, Bioabsorbable material placed to support the root and cover the perforation. P, Small syringe with graft material placed anteriorly first. Q, Sinus filled but not over-filled. R, Resorbable membrane positioned over the window. S and T, Clinical and diagrammatic views of final suturing. Suturing is a combination of horizontal tension-releasing mattress sutures followed by individual or contiguous incision-closing sutures.

Note: Care must be taken to avoid exposure and damage to the infraorbital nerve or foramen by overaggressive flap extension superiorly.

5. The flap is sutured back with 3-0 or 4-0 silk suture, with attention given to avoid damage to the parotid duct (Misch, 1992).

II. Bony Osteotomy and Intraoperative Bleeding

1. Computed tomography. The CT scan is carefully reviewed to determine the following:
 - a. Anterior, posterior, and medial sinus walls
 - b. Estimated sinus volume
 - c. Remaining residual alveolar ridge width overlying sinus
 - d. Thickness of the lateral sinus wall
 - e. Location of the bony septum
2. Transillumination (Rosenlicht, 1992). A fiberoptic light positioned palatally, facially, and intranasally may be helpful in further delineating or confirming the sinus boundaries, especially the anterior wall.
3. The lateral window osteotomy is begun with a no. 6 or no. 8 coarse round diamond bur in a high-speed or straight handpiece

(50,000 rpm). Copious sterile saline irrigation is used to prevent overheating of the bone.

Extreme care must be taken to avoid damage to the underlying schneiderian membrane during this procedure. For that reason, the bur is moved in a light paintbrush motion, stripping away the outer cortex until the membrane is visualized (appears gray or bluish). *Pressure is to be avoided as contact with the membrane will result in tearing.* The use of carbide cutting burs is recommended for the initial outlining only when the lateral wall is thick.

Note: The clinical tactile skills required are similar to those required to cut through an eggshell without cutting through the membrane beneath it (Vesson and Petrik, 1992).

4. The osteotomy is begun 3 to 4 mm above the remaining alveolar ridge, approximating the area of the first or second molar and proceeding forward. This will result in an approximate length of 20 mm. In this manner, the anterior and posterior limits of the osteotomy are established as previously determined and the window will be posi-

tioned inferiorly enough to permit horizontal membrane reflection. It also provides a “cup form” to help hold the graft material (Smiler and colleagues, 1992).

Note: Given that most septa are 1 to 3 mm (if present), the initial osteotomy will be made above most small septa.

5. The anterior osteotomy is positioned far enough forward so as to come within approximately 5 mm of the anterior sinus wall or the anterior extent of the surgery. Owing to a lack of direct visualization, anterior membrane reflection is the most difficult, and this will minimize the amount of forward membrane reflection required.
6. The anterior and posterior vertical osteotomies are approximately 20 mm from each other. They may be straight or rounded depending on whether the window shape will be rectangular or ovate.

Note: The ovate shape is easier to perform and will leave no sharp corner edges to tear the membrane when fractured.

7. The superior osteotomy is made approximately 10 to 15 mm above the inferior osteotomy depending on the width of the residual alveolar ridge (VRH-3 or VRH-4; see Table 27-2). It should be positioned superior enough to avoid having to carry out excessive superior membrane reflection. The osteotomy should not come within 4 to 5 mm of the superior border of the flap, thus avoiding inadvertent slippage of the flap retractor into or against the window (see Figure 27-9, E). The osteotomy is begun inferiorly 3-5 mm above the ridge to avoid small septa and act as a lip to hold the graft. Anteriorly, the osteotomy is started approximately 5 mm from the anterior extension of the sinus (see Figure 27-9F).
8. It is important to note that the membrane will first appear in discreet areas as a gray or bluish line or hue as it is approached. This is the first indication to clinicians that
 - They are almost through the lateral wall.
 - Care must be exercised not to perforate the schneiderian membrane.

The osteotomy is continued until the membrane is almost completely visualized (see Figure 27-9G and H).

9. During the osteotomy, gentle pressure is intermittently applied to the bony window with the flat edge of a bone chisel. This will permit the clinician to see if the window is freed or where further bone removal is required. Gentle tapping with a mallet on a flat-ended bone chisel is often all that is required to complete the osteotomy once the membrane is almost completely visualized. Rectangular-shaped windows often bind in the corners and require further reduction.
10. Once the window is completely freed, it can be retained or removed (Fugazzotto, 1994; Garg and Quiñones, 1997). If retained, it will become the superior wall of the sinus lift (see Figure 27-9, I and J).

The two main reasons advocated for removal of the bony window are as follows:

- The sharp bony edges may inadvertently tear the membrane.
- Removal will increase visualization when the malar buttress approximates the alveolar crest. If removal is desired, a Molton curet is used to detach the bony window from the membrane with the concave side of the instrument positioned against the bone.

Note: Most clinicians maintain the bony window and do not find the bony edges or increased visualization to be significant enough to justify removal. It will serve as a bony roof to pack the implant against. If removed, it is generally incorporated into the graft material.

Intraoperative Bleeding. Control of Bleeding. Since there are no major blood vessels at the surgical site, most bleeding is either extraosseous or intraosseous.

Extraosseous Bleeding (Garg, 1997, 1999).

1. Direct pressure with a moist saline gauze or packing the area with moist gauze
2. Topical or intraosseous injection of 1:50,000 local anesthetic
3. Use of a topical astringent
 - a. Gelfoam
 - b. Surgicel
 - c. Avatine

Intraosseous Bleeding.

1. Sterile bone wax is burnished into the bone
2. The bone opening is crushed, burnished, or gently infractured to close of the opening.

Note: The posterior wall should be avoided owing to the highly vascular pterygoid plexus.

III. Membrane Reflection

See Figure 27-8J.

1. With the window freed on all sides, the patient is asked to breathe in and out.
Membrane pulsation will mean that there is no tear at this time (see Figure 27-8, L and M).
2. The instruments for reflection are specifically designed so that their sharp edges are maintained in contact with the bone while their smooth convex surfaces lift and displace the schneiderian membrane off the bone. Some clinicians advocate slight dulling of the sharp edges to reduce membrane tears. Membrane reflection is carried out with gentle outward pressure, making sure that the curved edge of the instrument is always in contact with the bone.

A healthy sinus membrane is very thin and pliable yet thick enough to permit a successful sinus lift operation. A thickened membrane (smokers, previous sinus infections) is more resistant to tearing. The nature and quality of the membrane can often be visualized on the CT scan.

Note: The clinician should never blindly place or manipulate the curet and should always feel the instrument against the bony floor or lateral walls.

3. The first reflection is circumferential. A small tissue curet is introduced along the complete inner surface of the bony perimeter for 360°. This will initially free the membrane from any sharp edges of the bony window and/or surrounding bony walls. This will prevent inadvertent membrane tears.

Note: If the patient is asked to inspire, the initial reflection may be facilitated. This will draw the membrane inward and facilitate the removal of any sharp edges on the window margin.

4. Reflection is begun on the inferior border with a broad-based instrument and extended medially. Once the membrane is lifted inferiorly, lateral reflection is begun. Distal membrane reflection is not difficult because there is direct visualization by the clinician. This is in stark contrast to the anterior portion of the antrum, where there is no direct visualization.
5. Anteriorly, reflection is most difficult owing to a lack of direct visibility. The clinician must therefore strive to maintain the instrument in contact with the bone at all times. If the distance of anterior membrane reflection is greater than 5 to 10 mm or the instrument cannot stay in contact with the bone, the window should be enlarged to permit membrane reflection. This is accomplished with a small Friedman end-cutting rongeur after initial membrane reflection.
6. Superiorly, the membrane is raised so that the combined height of the membrane's position superiorly when added to the width of the residual bony ridge is about 16 to 20 mm from the crest of the ridge (Misch, 1999).

Note: It is always better to have more height than less.

7. Medially, it is recommended that the membrane be reflected to the medial wall to help with osteogenesis (Misch, 1996; Tarnow, 2004) (Figure 27-9N).

Membrane Tears. A torn or perforated sinus membrane is the most common complication during sinus graft surgery (Jensen and colleagues, 1994; Wheeler and colleagues, 1996; Froum and colleagues, 1998; Mazor and colleagues, 1999; Misch, 1999; Pikos, 1999). Chanavez (2000) pointed out that "a torn mucosal lining becomes a negative factor for graft material containment over the sinus floor and fails to prevent the transmission of a possibly contaminated graft, which may result in blockage of the osteum." Proussaefs and colleagues (2004) recently showed significantly less new bone formation in perforated sites (14.17%) when compared with nonperforated sites (33.58%).

Treatment of Membrane Tears. Circumlevation Technique. Misch (1999) described a Circumlevation technique that involved elevating the distal areas first while approaching "the tear from all sides, so the torn region may be elevated without increasing the opening size." This technique requires that tears approximating the bony

walls be identified, localized, and bypassed to prevent their enlargement. Fugazzotto and Vlassis (2003) recently outlined a classification system based on the location of the perforation. They recommend extension of the osteotomy opening to permit access for exposure of intact membrane beyond the perforations that will serve as support for the membrane materials to “seal” the opening.

Note: This is similar to the circumlevation technique (see Figure 27-10).

Membrane tears increase as sinus angulation decreases below 60° (Tarnow, 2004). Therefore, the membrane during reflection should be periodically checked for tears or perforations. This is accomplished by checking for membrane pulsation with patient respiration. Lack of membrane movement generally indicates that a hole or tear is present.

A. Small Tears. Small tears most often occur

1. During initial window osteotomy
2. During infracture of the lateral wall
3. Owing to instrumentation during sinus elevation

They are treated in two ways:

1. Some are self-sealing owing to the folds of the membrane and require no further treatment.
2. Small visible tears are simply treated by placement of Gelfoam, Surgicel, or Collatape (Garg, and colleagues, 1992; Rosenlicht, 1992; Fugazzotto, 2003)

Note: A bioabsorbable membrane placed on the roof will not only cover small tears if present but help prevent membrane damage during graft placement (see Figure 27-9).

B. Large Tears.

1. The tear may be sealed superiorly by placement of two layers of Collatape in conjunction with a suitable biodegradable membrane (Biomend, Resolute Adapt, BioGuide, Ossix). Lamella bone (Vassos and Petrik, 1992) may be added to form a stable roof against which to pack the graft material.
2. Large tears may also be treated by reflection of the membrane off the medial wall and folded over on to itself and then covered with a suitable resorbable membrane (Biomend, Resolute Adapt, BioGuide, Ossix).
3. If the tear is too large, it is sometimes best to consider stopping the procedure and after an appropriate healing time of 3 to 4 months repeating the procedure.

Note: The best way to prevent tears or perforations is by using careful osteotomy and the membrane reflection technique.

Loma Linda Pouch. A recent study by Proussafs and Lozada (2003) found that in most cases of sinus perforation, when a resorbable membrane is placed, “the graft material escaped beyond the confines of the schneiderian membrane.” They also reported no or minimal bone formation at the perforation site.

The Loma Linda pouch was developed to overcome these shortcomings, providing potentially superior graft material protection and isolation with greater bone formation (Proussafs and Lozada, 2003). It requires that a resorbable colla-

gen membrane cover the entire internal maxillary sinus surface, making sure that its edges extend beyond and are folded over the boundary of the lateral window osteotomy. The graft material is inserted into the pouch, which may be facilitated by use of a curet. The “pouch,” in conjunction with the membrane covering the lateral wall, completely isolates the graft material, prevents graft displacement, and may potentiate greater bone formation in the perforation site (Figure 27-10). Fugazzotto and Vlassis (2003) recently advocated a procedure very similar to the Loma Linda pouch, the only difference being the recommendation that “pins” be used for membrane stabilization. They also stated that “when faced with an extensive membrane perforation requiring the aforementioned reconstructive therapy, only augmentation is carried out during this surgical session.”

Note: The assumption that this technique will improve bone formation in the site of the perforation and prevent graft migration has been partially substantiated by Pikos (1999), who showed that successful sinus augmentation can be achieved after complete sinus removal and placement of a collagen membrane in conjunction with a graft material.

IV. Grafting the Sinus Floor

A. Graft Materials. All graft materials should promote osteogenesis by

1. Osteoconduction and/or
2. Osteoinduction

Bone grafting has been intensely studied by a number of clinicians (Boyne and colleagues, 1980; Smiler and colleagues, 1994; Lundgren and col-

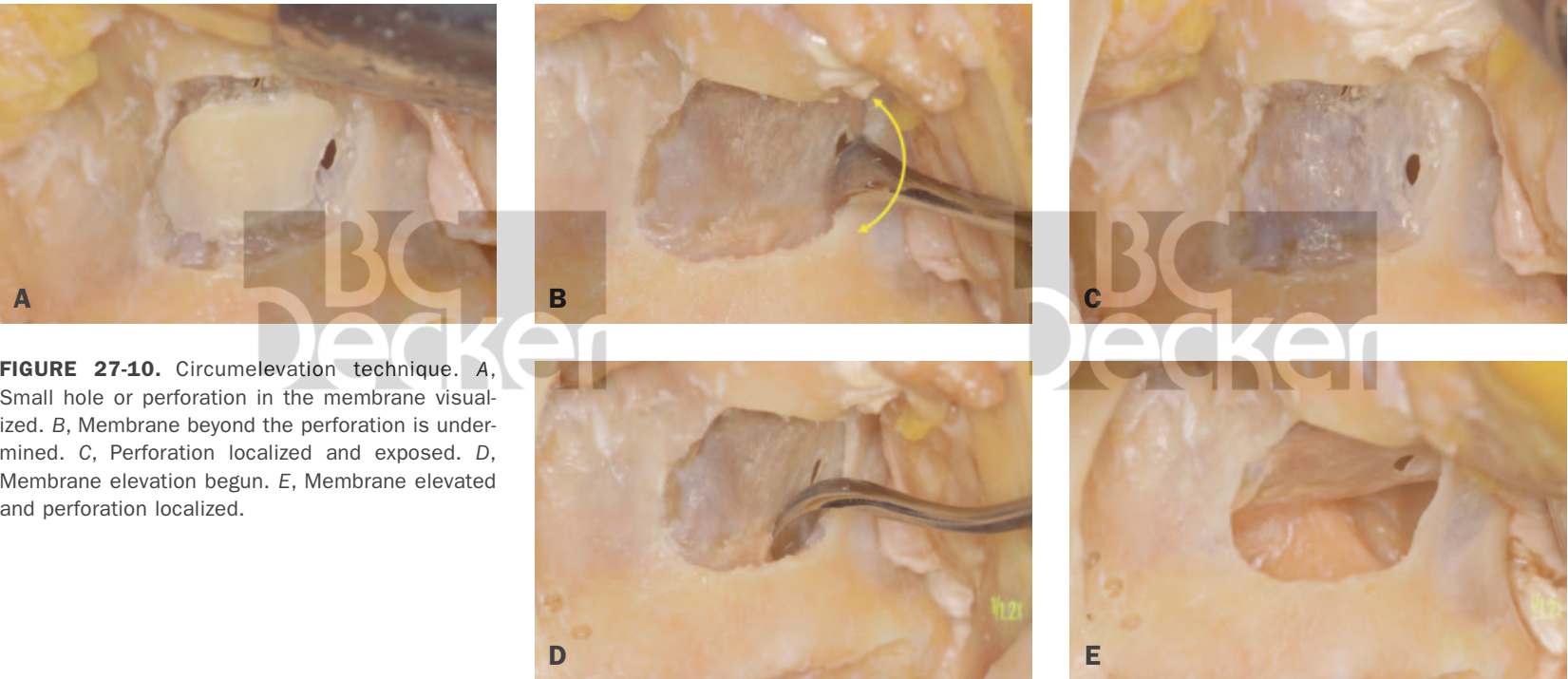


FIGURE 27-10. Circumlevation technique. A, Small hole or perforation in the membrane visualized. B, Membrane beyond the perforation is undermined. C, Perforation localized and exposed. D, Membrane elevation begun. E, Membrane elevated and perforation localized.

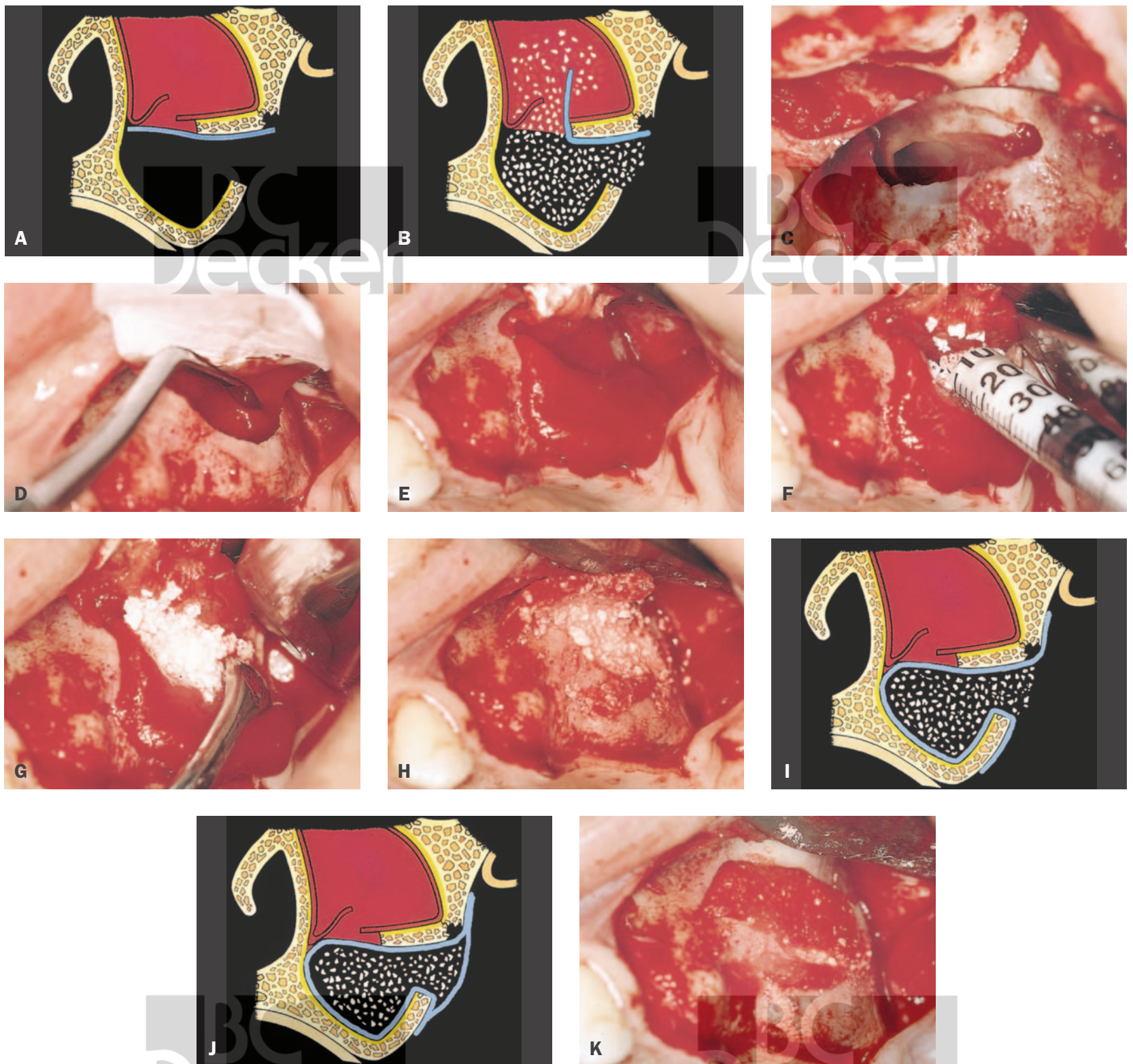


FIGURE 27-11. Loma Linda pouch technique. *A*, Placement of a collagen membrane has been proposed along the perforated site to seal the membrane perforation. *B*, Escape of graft material into the sinus area. Collagen membrane placed passively against the perforated site cannot resist the mechanical forces exerted when graft material is impacted into the sinus. *C*, Large perforation of the maxillary sinus membrane can be observed. *D*, Resorbable collagen membrane is inserted into the sinus area. A curet is used to facilitate the insertion. *E*, Collagen membrane covers the entire internal sinus area. *F*, Graft material is inserted into the pouch created by the membrane. *G*, Curet is used to further condense graft material into the maxillary sinus area. *H*, Placement of the graft material has been completed. *I*, Collagen membrane covers the entire internal maxillary sinus surface. *J*, The membrane is folded along the external sinus area, where a lateral access window osteotomy has been performed. The membrane forms a pouch to cover and isolate graft material. Mechanical pressure during graft placement cannot displace the membrane beyond the perforation site (as in *B*). *K*, Collagen membrane is folded along the lateral window site, forming a pouch that isolates the graft material. Courtesy of Dr. Periklas Proussaefs, Loma Linda, CA, and reproduced with permission from Quintessence Publishing Co.

leagues, 1996; Chanavaz, 1996, 2000; Valentini and colleagues, 1997, 2000; Jensen and colleagues, 1998; Tong and colleagues, 1998; Wood and Moore, 1988; Del Fabbro and colleagues, 2004; Wallace and Froum, 2004). Review of their work reveals that the walls of the sinus act similarly to that of an extraction socket or infrabony defect. That is, the bony walls not only house the implant but also provide the primordial endosteal, endothelial, and mesenchymal cells necessary for bony regeneration (Vlassis and colleagues, 1993). This is provided that an adequate space has been created between the sinus floor and the schneiderian membrane: “when little or no grafting material is used,...bone still forms as long as a space is maintained beneath an intact sinus lining to form a closed wound environment” (Nevins and colleagues, 1996). Misch (1996) and Wallace and Froum (2004) recommended exposure of the medial wall in all cases if possible to increase the source of bone-forming cells.

The availability and diversity of graft materials (autogenous, allografts, xenografts, alloplasts, and synthetics) have not only expanded faster than can be tested adequately but has also resulted in individual clinicians developing their own material combinations that they like to use. Fortunately, all materials reported appear to work satisfactorily, and although it is generally agreed that autogenous bone grafts are the gold standard by which all others are compared, composite grafts (94.88%) and bone substitutes (95.98%) compared favorably with autogenous bone (94%) if given enough healing time ($\leq 10\text{--}12$ months) and used with rough-surface implants (Wallace, 1996; Froum and colleagues, 1998; Jensen and colleagues, 1998; Misch, 1999; Valentini and colleagues, 2000; Del Fabbro and colleagues, 2004 ; Froum and Wallace, 2004).

Autogenous grafts.

- Advantages
 - Regeneration
 - More rapid healing
 - Greater bone density
 - Greater bone to implant percentage
 - No additional patient expense
- Disadvantages
 - Second surgical site
 - Greater morbidity
 - Increased patient anxiety
 - Dimensional instability: “greater graft shrinkage”

Nonautogenous bone grafts.

- Advantages
 - Predictable results (similar to autogenous bone)
 - Decreased morbidity
 - Decreased patient anxiety
 - Dimensional stability: “less graft shrinkage”
 - Unlimited supply

- Disadvantages
 - Greater cost
 - Longer healing time

Calcium sulfate (CaSO_4) added to any graft as a biologic expander (4:1 ratio of graft to CaSO_4) will (Sottosanti and Horowitz, 2003; Guarnieri and colleagues, 2004)

- Prevent overcompaction of graft material
- Promote angiogenesis and osteogenesis
- Increase the rate of graft turnover
- Decrease healing time
- Result in larger quantities of vital bone

Tarnow (2004) pointed out that vital bone formation is dependent on the following:

- Time ($\geq 12\text{--}15$ months)
- Graft dependent
 - Particular
 - Autogenous or anorganic bovine bone
- Membrane use

Note: It is strongly recommended that clinicians do a careful and critical review of the literature before deciding on a graft material or combination of materials with which they feel comfortable.

There have been four major reviews or meta-analysis studies on the survival rate of implants placed into grafted maxillary sinuses (Table 27-4).

These studies also found the following:

- The success rates for grafted sinus implants were similar to those for implants conventionally placed into the posterior (92% vs 95.1%) but significantly higher than the rate for implants placed in type IV bone (Jaffin and Berman, 1991) (92% vs 65%).
- Rough-surface implants have a significantly higher survival rate than machined implants when placed into grafted sinuses (95.111% vs 82.4%).
- Particulate grafts have a significantly higher rate of implant survival in grafted sinuses than block grafted implants (92.3% vs 83.3%).
- Lateral wall membrane placement resulted in significantly higher implant survival rates (93.6% vs 88.7%).

- Simultaneous versus delayed implant placement resulted in no difference (89.7% vs 89.6%).
- Plasma-rich protein appears to be most effective when autogenous bone grafts are used.

B. Graft Placement

- The graft material(s) is placed in a dappen dish and moistened with sterile saline.
- The addition of an antibiotic (amoxicillin 500 mg, clindamycin 150 mg) may be added to the graft. This may be helpful in reducing infection, but its use is totally dependent on the individual clinician’s protocol.
- A 1 cc tuberculin syringe is used as the implant carrier

Note: Precut sterile 1 cc syringes are available from CeraMed and Ace Surgical Supply.

If the tip is present, it is removed with a no. 15 scalpel blade (Gargand Quiñones, 1997), making sure that all sharp edges are removed to avoid inadvertent membrane tears. The syringe is filled by forcing the implant material into the front end as the syringe is pressed into the graft material. This may be performed by the surgical assistant and be readied prior to use.

It is recommended that two or three syringes be used to expedite the transfer of graft material (see Figure 27-9P).

- The sinus is filled anteriorly and medially first by placement of the syringe into the sinus and discharging the graft material (Smiler and Holms, 1987). This will ensure that the most difficult areas to reach are adequately filled first. It will also provide initial stabilization of the membrane superiorly and medially.

Note: If implants are to be placed simultaneously, filling will be completed after implant placement.

- If simultaneous implant placement is not being considered, then the rest of the sinus is now filled medially and posteriorly. The graft is packed firmly by gentle pressure to ensure adequate density of material yet not too tightly as to possibly restrict blood supply,

Table 27-4 Survival Rate of Implants in Grafted Sinuses			
Study Patients	Implants	Sinus Lifts	Success Rates (%)*
Jensen et al, 1998	2,997	1,007 sinus lifts	90
Tong et al, 1998	1,097	295 patients	93
Wallace and Froum, 2004	5,277 sinus lifts	2,178	92.6
Del Fabbro et al, 2004	6,990	2,046 sinus lifts	91.5

*The exact nature of the graft material was not a significant factor in determining the final success rate as long as enough healing time was permitted ($\geq 10\text{--}12$ months) and rough-surface implants were used. Tarnow and colleagues (1998) showed that between 6 and 9 months, vital bone was 24% (range 9–34%), whereas between 12 and 15 months, vital bone was 33% (10–65%).

oxygen, and/or other components necessary for graft success.

Note: Care must be exercised not to overpack the graft material or place excessive pressure on it, which may result in tearing of the sinus membrane. This is especially true when there are already treated tears or perforations.

6. The sinus is considered filled when the graft material is level with the lateral wall (see Figure 27-9Q).

Note: There is no benefit to overfilling the sinus.

C. Simultaneous Implant Placement.

1. If there is a minimum of 5 mm of residual alveolar ridge height (SA-3 [see Table 27-1]; VRH-3 [see Table 27-2]) and primary implant stability is possible, then implants can be placed simultaneously. Performed properly, there is no difference in implant success rates between staged and simultaneous placement (Jensen and colleagues, 1998 [83.9% vs 85.5%]; Tong and colleagues, 1998; Del Fabbro and colleagues, 2004 [92.93% vs 92.17%]; Wallace and Froum, 2004 [89.7% vs 89.6%]).
2. During implant placement, the superior wall, if not adequately supported by graft material, is reflected to prevent damage during implant placement. Once placed, the implants will stabilize the superior portion of the sinus.
3. The rest of the sinus is now filled medially and posteriorly.

D. Membrane Placement on Lateral Wall. The nature, type, and use of a membrane have still not been firmly established.

Although the sinus will heal without the use of a membrane, membrane use provides maintenance of the lateral wall, prevention of ingrowth of connective tissue, increased graft density, and a greater percentage of vital bone (11% without vs 25% with) (Tarnow and Froum, 2000). The use of a membrane also results in significantly higher implant survival rates (93.6% vs 88.7%) (Wallace and Froum, 2004).

The only question pertains to the nature and quality of the membrane: resorbable versus non-resorbable. Until such time that there is clear evidence that one membrane outperforms another, it is recommended that a resorbable membrane be used. This will decrease the chance of secondary infection owing to membrane exposure and the need for possible additional surgical procedures for premature removal (see Figure 27-9R).

Flap Closure.

1. A suitable suture material (Gore-Tex, Vicryl, Dexon) should be used to permit flap stabiliza-

tion for 2 to 3 weeks without infection. Gore-Tex sutures, because they are biologically inert and can be left in position for long periods without breakdown or secondary inflammatory reactions, are the sutures of choice.

2. One, two, or three horizontal mattress sutures are placed first. This will relieve incision line tension, help ensure primary flap closure, and invert the flap margins against themselves.
3. Interrupted and/or continuous sutures are used for final closure of the vertical and palatal incisions (Figure 27-9, S and T).

VI. Postoperative Instructions and Medication

1. Peridex (3–4 weeks or until the area has stabilized)
2. Ultraswave toothbrush (PHB)
3. Soft diet (4 weeks or until the area has stabilized)
4. Analgesics as required
5. Amoxicillin 500 mg three times daily for 10 days
6. Instruct patients not to blow their nose for a week and if they sneeze to keep their mouth open.
7. No smoking.

VII. Postoperative Complications:

A. Acute Maxillary Sinusitis. The sinus graft, although considered a safe procedure (Peleg and colleagues, 1999a, 1999b; Ziccardi and Betts, 2000; Raghoobar, 2001; Schwartz-Arad and colleagues, 2004), does have some complications.

Tatum (1986) stated that the primary complication of the sinus implant was postoperative infection, which has been reported as low as 3%, whereas Marx and colleagues (1981), in their review of the literature, found the complication rate to range from 17.6 to 50%. The proximity of vital structures dictates that before undertaking these procedures, it is strongly recommended that the clinician establish a working relationship with an ear, nose, and throat specialist.

If the patient presents with acute maxillary sinusitis (facial pain, tenderness, swelling, purulence, fever), a thorough examination should be undertaken. If purulence is present, a culture and sensitivity test should be performed and the patient aggressively treated empirically with antibiotics. The following antibiotic regimen is recommended by Misch (1992) and should last for 10 to 14 days:

1. Combination
 - a. Augmentation 500 mg to 1 g every 6 hours should be substituted for amoxicillin. The presence of clavulanic acid will control beta-lactamase-producing organisms.

- b. Metronidazole (Flagyl) 250 mg three times daily will control the anaerobes.
- or
2. Clindamycin (Cleocin) 300 to 450 mg to start followed by 150 to 300 mg three times daily. Chlorhexidine gluconate oral rinses are also recommended.

Note: If there is no resolution of the infection and purulence persists, the graft may have to be removed. "If symptoms do not improve or begin to worsen, the patient should immediately be referred to a specialist for consultation and evaluation."

B. Incision Breakdown Dehiscence. Prevention is the best way to treat these problems. Incisions should be made far from the surgical area and the flap undermined adequately to permit tension-free closure.

Membrane exposure will require premature removal to prevent infections. Graft exposure may necessitate part or complete removal. Small fistulae will generally heal over a period of time, and chlorhexidine and saline rinses should be used to reduce bacterial infiltrate.

Summary and Conclusions

1. Use of the Caldwell-Luc lateral approach for sinus lifts is predictable and attainable using a variety of different graft materials.
2. No minimal amount of residual bone is necessary for predictable sinus augmentation.
3. Simultaneous implant placement and sinus augmentation is predictable if
 - a. A minimum amount of residual bone is present
 - b. Initial implant stability is achievable
 - c. The implant is completely surrounded by bone
4. The longer the sinus is permitted to heal, the higher the success rate.

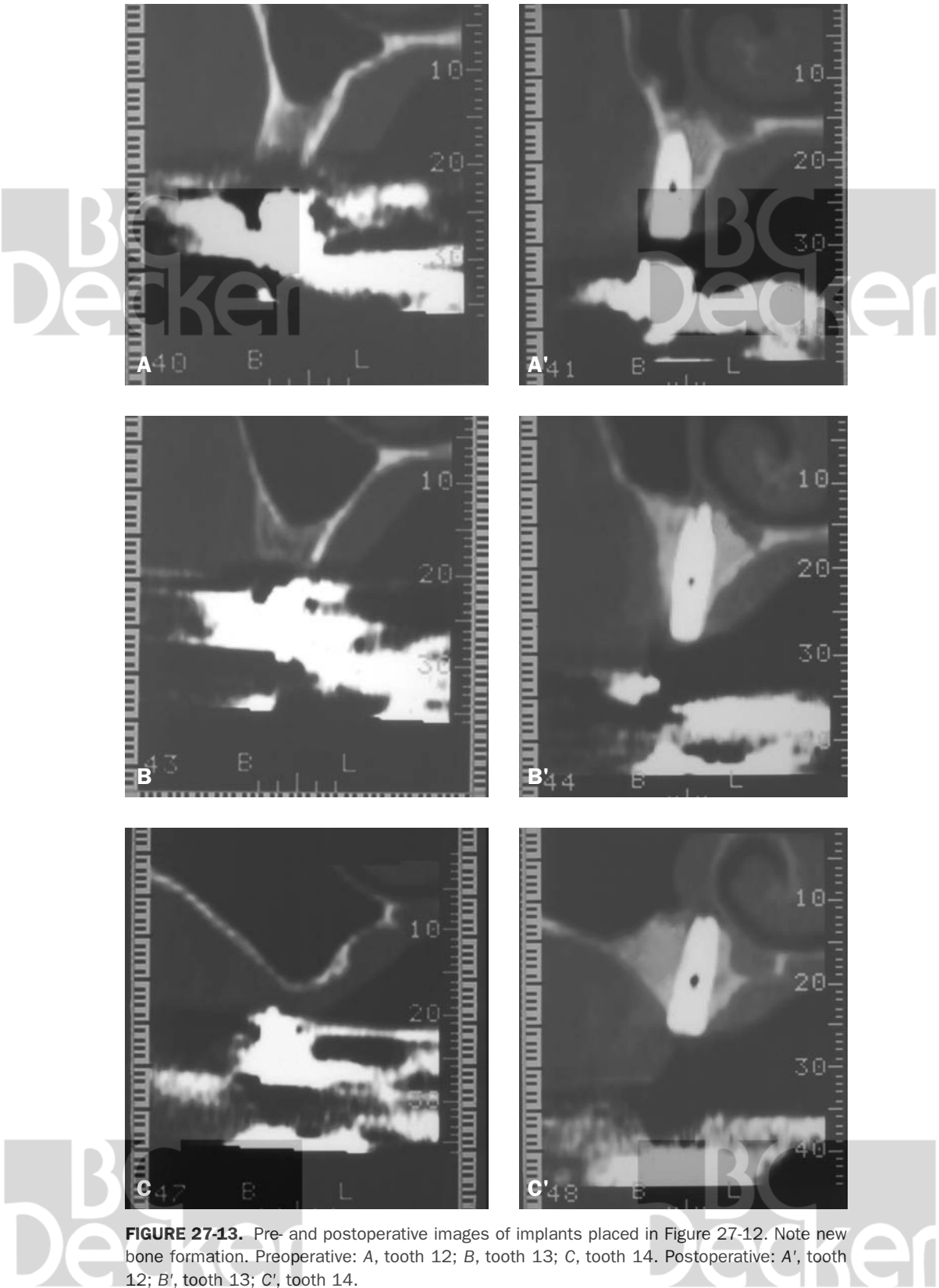
Therefore, it is recommended that whether immediate or staged implant placement is performed, 12 to 14 months should be allowed for complete osseointegration.

Note: To avoid unnecessary problems, clinicians who are not thoroughly familiar with this procedure should avoid simultaneous implant placement.

The clinical cases are depicted in Figures 27-12 to 27-15.



FIGURE 27-12. Prosthetics, progressive loading, and occlusal design. *A* and *B*, Clinical and radiographic preoperative views. *C* and *D*, Postoperative radiographic results after sinus lift and implant placement, staged approach. *E*, Healing abutments placed. *F*, Custom abutments, occlusal view. Note center positioning. *G*, Custom abutments, facial view. *H*, Radiographs of custom abutments. *I*, Temporization. Progressive loading for 6 months; cuspid-protected, occlusion-reduced, inclined planes; reduced occlusal table size; and contact only in centric or habitual occlusion. *J*, Final prosthetic radiograph. *K*, Final occlusion reproduces that of provisional crowns. *L*, Final crowns, occlusal view. Note the reduced occlusal table and inclined planes.



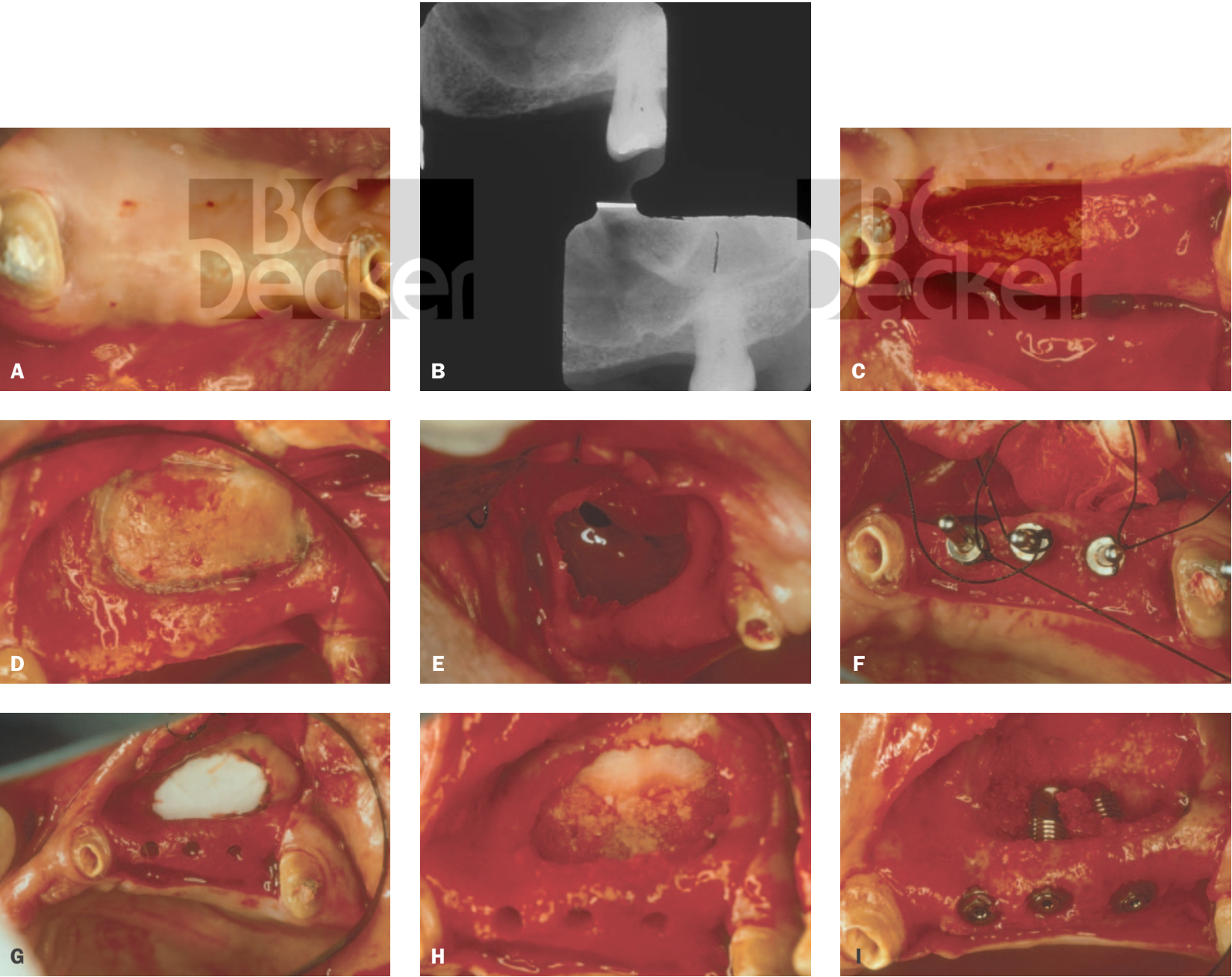


FIGURE 27-14. Sinus lift, sinus membrane perforation, and immediate implant placements. *A and B*, Preoperative clinical and radiographic views. *C*, Palatal incision placed far from the window. *D*, Window outlined. *E*, Bony window removed and sinus lifted. Note sinus perforations (two). *F*, Implant sites prepared. Note the parallelism of the directional probes. *G*, Bioabsorbable materials positioned to cover the perforation and support the roof. *H*, Freeze-dried bone allograft placed on the medial surface prior to implant placement. *I*, Implants positioned.

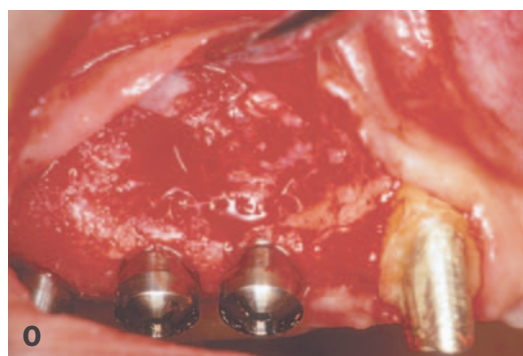
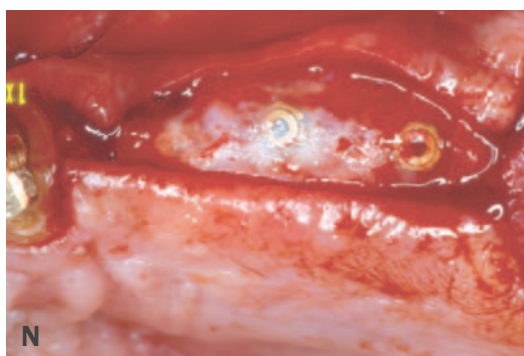
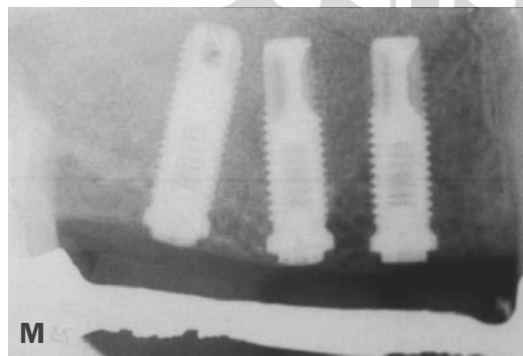
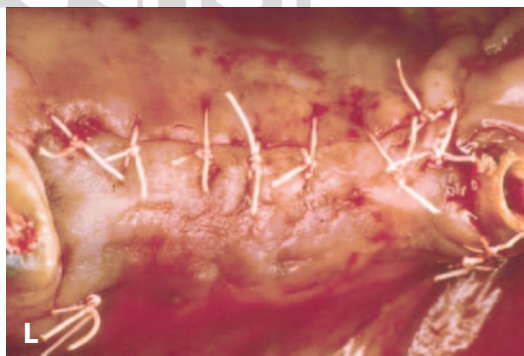
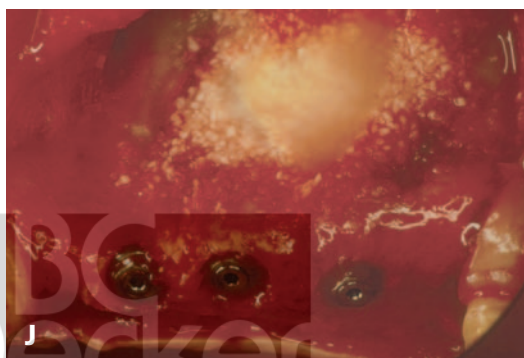


FIGURE 27-14. *Continued.* J, The sinus is completely filled with freeze-dried bone allograft. K, Gore-Tex is trimmed prior to placement over the window. L, Flap closure with the incision line far from the sinus window. M, Radiograph of implants 12 months postoperatively. N, Gore-Tex removed at the time of abutment placement. O, Healing abutment positioned. Note complete healing of sinus. P, Final healing prior to prosthesis.

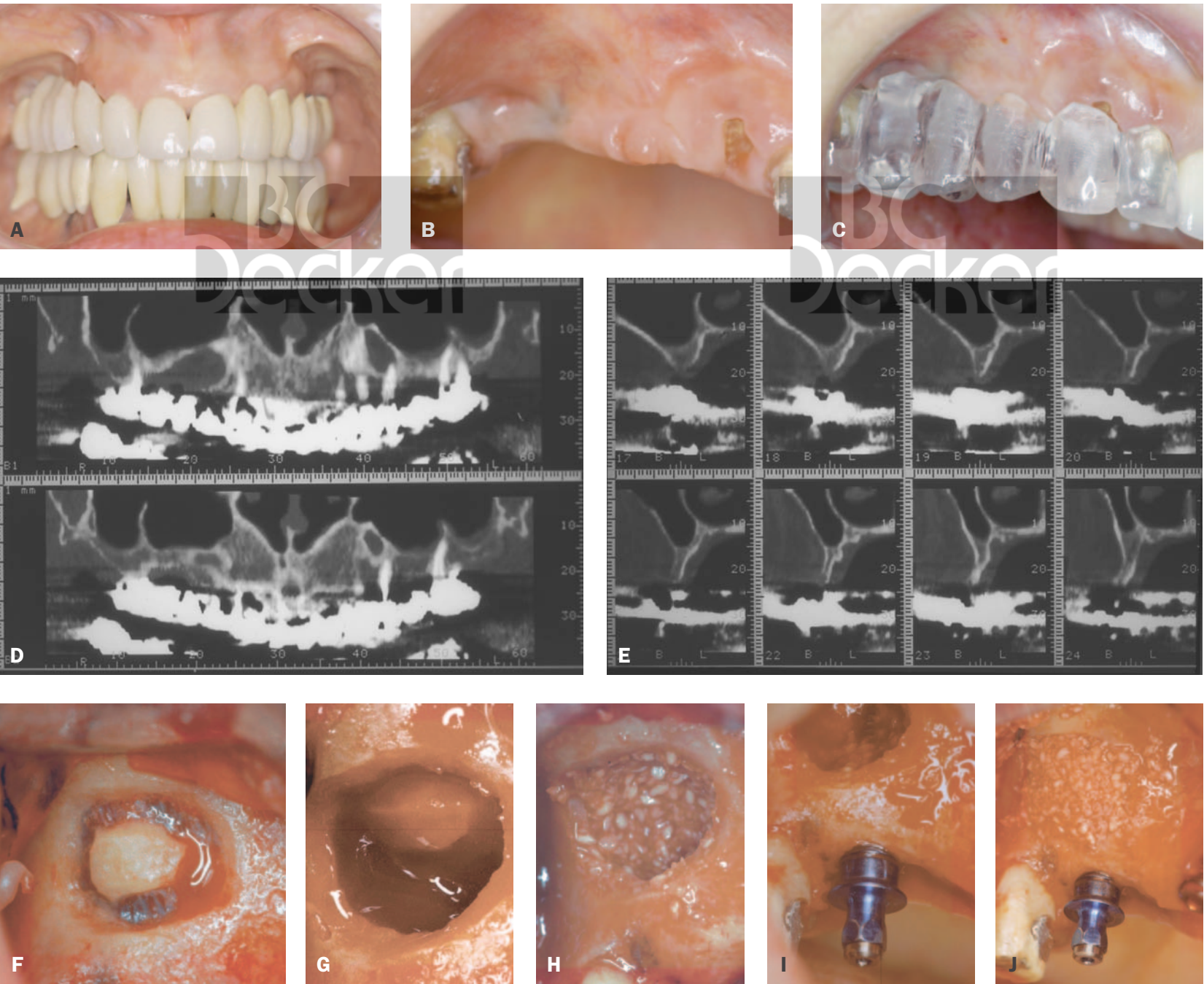


FIGURE. 27-15. Guided tissue regeneration. Immediate loading. *A*, Preoperative view with a temporary bridge in position. *B*, Preoperative view of the edentulous ridge. *C*, Surgical stent in place duplicates final temporary bridge. *D*, Panorex radiograph showing a large bony septa. *E*, Cross-sectional views showing a thin edentulous ridge. *F*, Sinus window outlined. Note blue hue of sinus. *G*, Window reflected. Sinus lift complete. *H*, Graft material (FDBA) placed anteriorly, medially, and occlusally prior to implant placement. *I*, Implant placement into sinus. *J*, Sinus fill complete with FDBA.

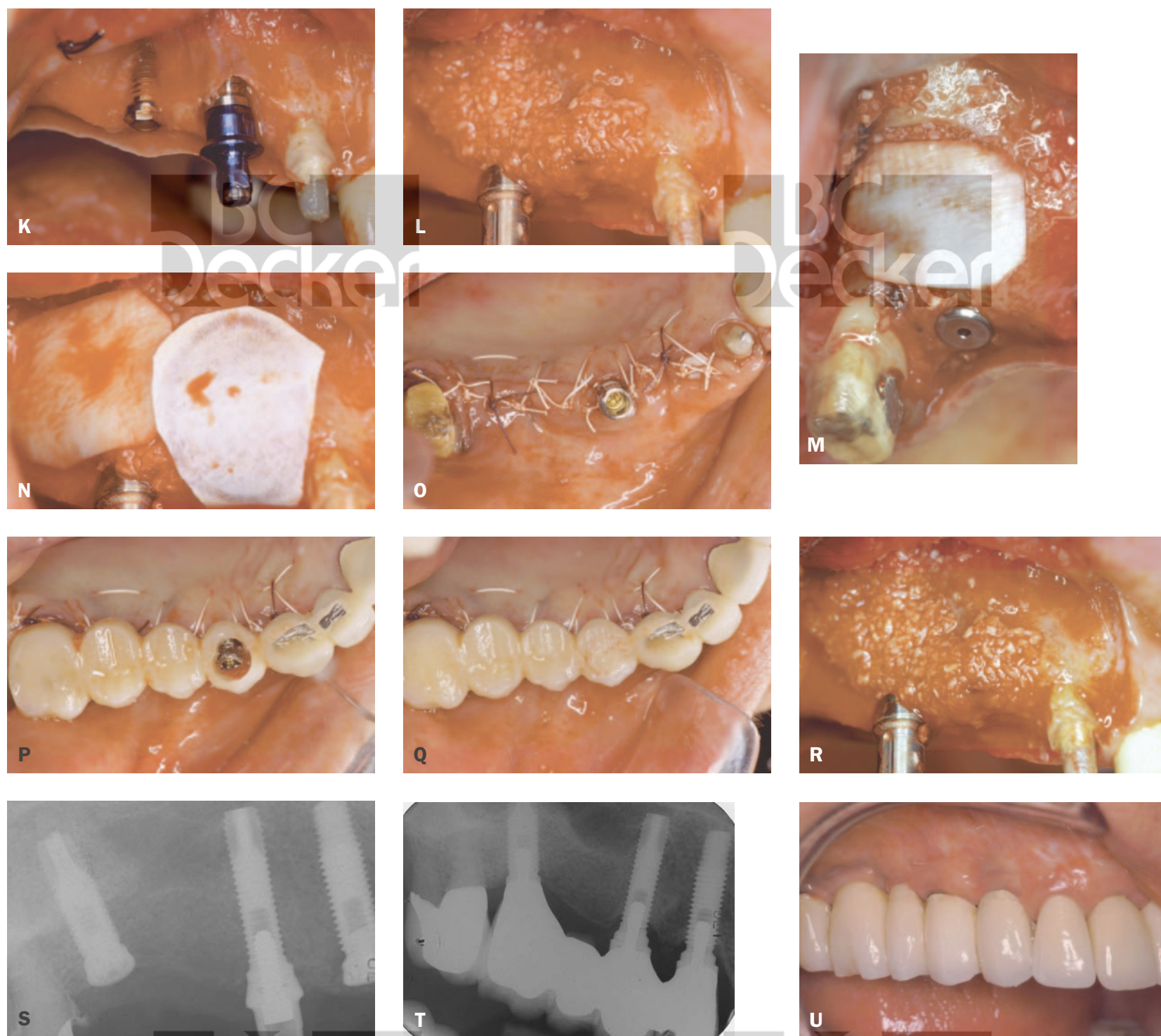


FIGURE. 27-15. *Continued.* K, Immediate implant placement into extraction socket (#6). Narrow implant placed in ridge for immediate loading. L, FDBA placed over buccal dehiscence and extraction site implant. M, resorbable membrane placed over sinus opening. N, Resorbable and nonresorbable membranes placed. O, Final suturing with custom abutment placed in implant. P, Temporary bridge positioned over the implant. Note ideal positioning of implant within temporary bridge. Q, Self-curing acrylic is placed into temporary bridge. R, Two months later at the time of nonresorbable membrane removable. Note early bone formation as compared to resorbable membrane. S, Radiograph at time of implant placement. T and U, Radiograph and clinical view of final case 5 years later.



Mandibular, Ramus, and Allogeneic Block Bone Grafts

The dental or periodontal surgeon has a number of choices of donor sites or sources for bone grafts prior to and during implant surgery or bone augmentation for other purposes when a block graft configuration is required and/or desired. Using an intraoral donor site allows the clinician to operate in the same field as the recipient site and eliminates the need for cutaneous scarring.

The mandibular symphysis represents a viable alternative for small grafts frequently used for implant procedures. The anterior mandible provides the block grafts and particulate bone necessary to augment and mortar the periphery of the block graft. The symphysis can provide a sufficient amount of block bone for increasing width deficiencies by 4 to 7 mm, length deficiencies of 15 to 20 mm (about one to three teeth), and height by 10 mm. Studies suggest that the site can yield an average block of $21 \times 10 \times 7$ mm or more. The anterior mandible donor site offers relatively moderate morbidity and minimal graft resorption following placement. The symphysis has been used to restore many types of defects, including class III ridge defects (both vertical and buccal bone loss) in the anterior maxilla and other locations (as block configuration), and for sinus elevations (as particulate and/or block configurations). As biologic, mechanical, and topographic aspects of the mandible confirm, the most popular graft donor sites are chosen for their cancellous cellular density or for block configuration to provide structural support.

Ramus grafts yield a rectangular piece of bone approximately 4 mm thick, 30 mm or more in length, and up to 10 mm in height. This graft morphology is especially well suited for use as a veneer graft to increase ridge width from one to four tooth sites. Twice this amount of bone can be obtained if it is harvested bilaterally. Studies have shown that the ramus is a good source of autogenous bone for ridge augmentation procedures but does not provide any cancellous particulate graft material.

In addition to intraoral donor sites, allogeneic bone allografts have been used for years as viable alternatives to autogenous grafts. Additionally, allogeneic bone graft materials offer a number of distinct advantages to autogenous donor sites. They eliminate many of the disad-

vantages associated with autogenous grafts, including morbidity, limited volume and dimension of bone, and harvesting time. These materials have been widely used as particulate (demineralized freeze-dried bone allograft [DFDBA], freeze-dried bone allograft [FDBA]) for years in periodontal, oral surgical, and dental applications. They have also been used for years in block configurations but infrequently in oral applications and extremely frequently in orthopedic applications. They are now increasingly gaining acceptance for oral bone grafting and will continue to be used more frequently as availability and costs become more acceptable.

For allogeneic blocks, no harvest is required; however, it is important to obtain these blocks from a reputable tissue bank accredited by the American Association of Tissue Banks (AATB). It is also critical to recognize that the use of this material requires a slightly modified approach compared with autogenous bone blocks.

Mandible, Ramus, and Allogeneic Bone as Donor Sites or Sources

The efficacy of using the symphysis, ramus, and allogeneic bone as donor sites or sources is outlined in detail below. Table 27-1 presents a summary of criteria related to the two mandibular

donor sites and to allogeneic sources of block graft material.

Donor Sites

I. Mandibular symphysis grafts

A. Advantages

1. Good bone quality
2. Short healing period
3. Good maintenance of graft volume
4. Excellent implant stability owing to dense structure
5. Easy access
6. Good thickness of bone over other intraoral sites
7. No alteration in ambulation
8. Bone quality more favorable than guided tissue regeneration
9. Simulating effect of implant placement on bone, maintaining graft volume and preventing further loss

B. Disadvantages

1. Possible limited availability of bone
2. Potential damage to mandibular roots
3. Potential mental nerve paresthesia
4. Altered sensation of lower teeth
5. Potential "ptosis" of the chin
6. Generally requires intravenous anesthesia
7. Requires experienced and trained surgeon to perform

Table 27-1 Comparison of Mandibular Donor Sites/Sources

Parameter	Symphysis	Ramus	Allogeneic Block
Surgical access	Good	Fair to good	NA
Patient cosmetic concerns	High	Low	NA
Graft shape	Thick rectangular block	Thinner rectangular veneer	Thick triangular or rectangular block
Graft morphology	Corticocancellous	Cortical	Corticocancellous
Graft size (cm ³)	> 1 cm ³	< 1 cm ³	> 1.5 cm ³
Graft resorption	Minimal	Minimal	Minimal to moderate
Healed bone quality	Type 2 > type 1	Type 1 > type 2	Type 2 > type 1
Donor site complications			
Postoperative pain/edema	Moderate	Minimal to moderate	NA
Neurosensory changes—teeth	Common	Uncommon	NA
Neurosensory changes—tissue	Common (temporary)	Uncommon	NA
Incision dehiscence	Occasional (vestibular)	Uncommon	NA

NA = not available.

C. Contraindications

1. Long anterior tooth roots
2. Short anterior mandibular height
3. Bone defects involving a span of more than four teeth
4. Gross vertical bone loss

D. Complications

1. Incision dehiscence in donor area
 - a. Vigorous chin musculature
 - b. Hematoma
 - c. Postoperative edema
 - d. Frenectomy
2. Chin ptosis from failure to preserve the mentalis muscle attachment
3. Excessive bleeding

E. Surgery

1. Preoperative evaluation
 - a. Clinical evaluation
 - i. Zone of keratinized gingiva
 - ii. Periodontal disease
 - (a) Tissue inflammation
 - (b) Bone loss
 - iii. Musculature
 - (a) Strong
 - (b) Weak
 - iv. Frenum
 - v. Vertical height of the mandible
 - vi. Presence or absence of teeth
 - b. Radiographs
 - i. Panorax
 - (a) Map course of inferior alveolar
 - (b) Evaluation of donor site
 - (c) Mental foramen location
 - (d) Size of the mandible
 - ii. Periapical
 - (a) Determine length of the roots
 - (b) Diagnose apical pathology
 - iii. Lateral cephalometry (thickness of chin) to provide an estimate of the buccolingual width for determining an estimate of graft thickness
2. Surgical technique
 - a. Presurgical medications: 1 hour prior to surgery
 - i. 1 g of amoxicillin or 300 mg of clindamycin if the patient is allergic to penicillin
 - ii. Chlorhexidine gluconate prior to surgery (at the start of the procedure)

Note: To reduce swelling, dexamethasone (3 mg twice daily) can be used the day of surgery and continued for several days afterward.

b. Surgical procedure

- i. Intravenous sedation with appropriate medications
- ii. Local anesthesia
 - (a) Bilateral mandibular nerve block

with 0.5% bupivacaine (1:200,000 epinephrine)

- (b) Local infiltration with 2% lidocaine, 1:50,000 or 1:100,000 epinephrine to enhance hemostasis
- ii. Incisions: Vestibular or sulcular incisions vary with the anatomic structures, local musculature, and periodontal status (Figure 28-1).

(a) Indications

- (i) Vestibular incisions (Figure 28-2)

Alveolar bone loss

Gingival inflammation

Easier access

Permits postsurgical double-flap suturing

- (ii) Sulcular incisions (Figure 28-3)

Shallow vestibule

Tense mentalis muscle

- (b) A beveled incision is made with a no. 15 scalpel at least 6 mm beyond the mucogingival junction down to bone. The beveled incision will help prevent wound dehiscence and leave exposed periosteum over bone to help anchor the flap postsurgically.

Note: With wide zones of keratinized gingiva present or a short mandible, a sulcular incision may be used.

- (c) The incision is extended bilaterally to the cuspids. Limiting the distal extent of the incisions will significantly reduce the incidence of temporary mental nerve paresthesia to less than 10% with no cases of less than complete recovery.

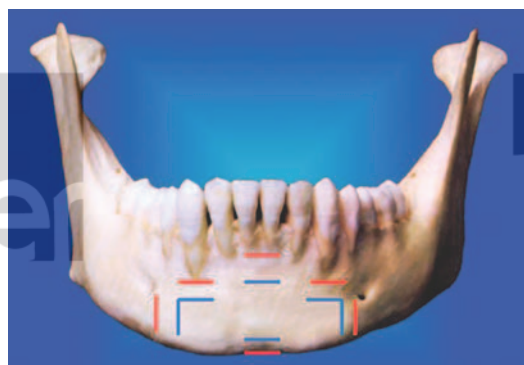


FIGURE 28-1 The vital structures in the area of bone harvesting are indicated in red. Generally, a minimum of 5 mm distance should be maintained from these vital structures when bone block (outlined in blue) is harvested. The blue outline indicates the maximum size of the block to be harvested from this area.



FIGURE 28-2 A vestibular incision (shown here) or intrasulcular incision is made to harvest bone from the anterior mandible.

Therefore, exposure and localization of the mental nerve and foramen should be avoided.

Note: Unless the clinician is very experienced, the graft should be confined within the cuspid area; therefore, lateral extension is unnecessary.

- (d) A periosteal elevator is used to reflect the mucoperiosteal flap toward the base of the mandible to the level of the “pogonion” (most anterior point of mandible), thus ensuring that the inferior border of the mandible remains intact. This will leave the most facial aspect of the periosteal attachment intact and prevent “ptosis” of the chin by avoiding “degloving” of the mandible.
- iii. Osteotomy for graft harvest
 - (a) The size of the osteotomy is determined by the size of the defect. Depending on the volume require-



FIGURE 28-3 A clinical case depicting a reflected flap with an intrasulcular incision design with mental foramen exposed and visualized to minimize chances of damaging its contents.

ments, the osteotomy may be extended between the canine roots but not beyond or below them if a greater graft size is required.

- (b) The superior osteotomy is made at least 5 mm below the apices of the teeth. **Note: This distance must be carefully evaluated pre-surgically.**
- (c) Since the cortical plate varies in thickness, outlining the graft with a series of small, round depth holes that extend through the outer cortex will facilitate the process. These holes are then connected with a no. 1701 or Lindemann bur in a high-speed hand piece under copious irrigation (Figures 28-4 to 28-6).
- (d) The inferior osteotomy is made so as to maintain the inferior cortex of the mandible (at least three superior to the inferior border of the mandible) (Figures 28-7 and 28-8).
- (e) The osteotomies are performed with a high-speed handpiece or a surgical saw using copious sterile saline irrigation. **Note: It is not necessary to leave a midline strip of intact bone.** Intact sectioning in the midline may facilitate graft removal.
- (f) The depth of the osteotomies extends completely through the cortical plate of bone.
- (g) A bone chisel (flat, curved) is “gently” tapped along the superior and lateral aspects of the osteotomy (Figure 28-8 and 28-9).

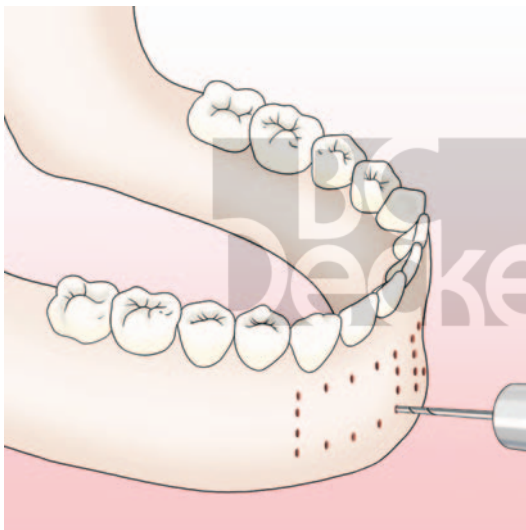


FIGURE 28-4 A template of the defect is used to outline the size and shape of block needed from the anterior mandible.

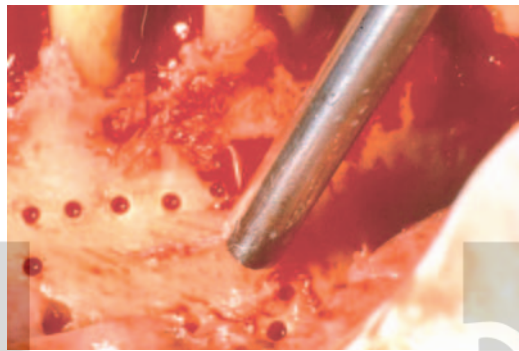


FIGURE 28-5 Clinical case showing the outline created around a template to obtain the correct size of bone block. Round holes serve as depth cuts to help determine thickness at the cortical plate.

Note: Avoid the inferior border to reduce the chance of fracture.

- (h) The osteotomy is then lifted with an angled chisel (45°).
- (i) Additional cancellous bone procurement is accomplished with a small Moldt curet or Friedman ronguer.

Note: Additional bone removal should cease once the lingual cortical plate has been encountered.

- (j) The graft and cancellous bone are now placed in sterile saline, which will maintain the viability of the progenitor cells for up to 4 hours owing to the osmotic gradient being equal.

Note: It is imperative that harvested endosteal osteoblasts and cancellous marrow stem cells be transferred to the jaw in a viable state and placed into tissue of sufficient vascularity to diffuse cell nutrients before revascularization. A more permanent vascular network is formed when new capil-

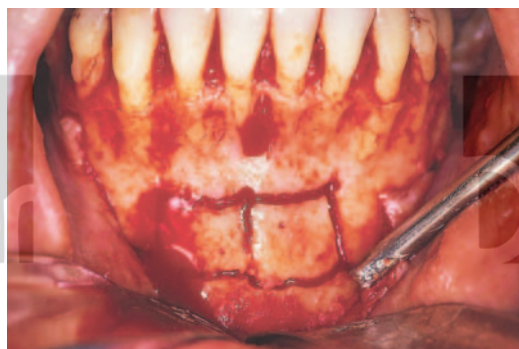


FIGURE 28-6 The bone blocks have been cut. The cuts can be made with a no. 1701 Brasseler bur or small saw. The individual depth cuts are now combined with a no. 701L or Linderman bur (Brasseler) or a small saw. The bone blocks are now cut assuming the final vertical and horizontal cuts are completely through the cortical plate.

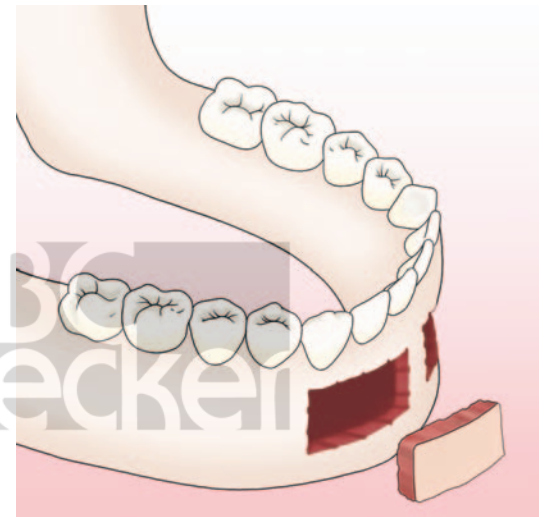


FIGURE 28-7 The outline is then cut to the proper depth depending on the thickness of block graft required and then removed with chisels.

laries bud into the graft. When properly stored, osteocompetent marrow cells can live outside natural bone up to 4 hours, losing no more than 5% viability.

3. Donor site closure: The most common patient concern is the postoperative appearance of the chin or chin deformity. This requires the clinician to take additional steps.



FIGURE 28-8 The blocks are luxated with small elevators and then fractured out with a curved chisel lightly tapped with a mallet. The chisel is generally placed on the mesial vertical cut.

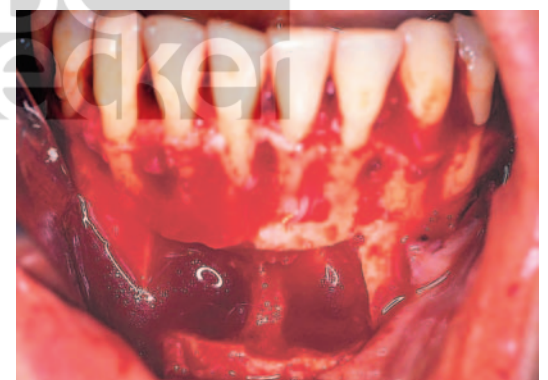


FIGURE 28-9 The bone block has been removed.

Radiographic evidence of incomplete bony regeneration, although reported, can be avoided with grafting.

4. Grafting the donor site (Figures 28-10, 28-11)
 - a. Excessive bleeding, if present, is controlled by placement of sterile hemostatic dressing (collagen or gelatin sponge) first into the areas of heaviest osseous bleeding.
 - b. To restore the chin profile, place a resorbable bone (FDBA, DFDBA) or bone substitute into the defect, preferably in a putty form.
 - c. CollaTape is now used to cover the entire graft site, containing the graft while acting as a hemostatic agent.
5. Suturing: Placing a fill material at the donor site can reduce deformation risk, as can the clinician not completely degloving the mandible; most importantly, the clinician must suture the tissues back to their original position. Therefore, this is an especially important area and step to perform meticulously.
 - a. A “two-layer flap” is used for
 - i. Tension reduction
 - ii. Flap stability
 - iii. Edema prevention
 - iv. Ptosis of the chin avoidance
 - b. Periosteal flap
 - i. The underlying or periosteal flap is sutured with interrupted (4.0, 5.0, or 6.0) chromic or Vicryl sutures.
 - ii. With a small tissue forceps to stabilize the most coronal portion of the periosteum, the suture needle is passed through the outer surface of the periosteum and on through the exposed periosteum from the original incision. This procedure is continued along the entire incision until periosteal closure is completed.
 - c. Mucosal flap

- i. The mucosal flap is sutured with interrupted 5-0 Vicryl sutures.
- ii. The mucosal flap is picked up and secured with tissue forceps. The needle is passed through the outer portion of the mucosal flap and through the undersurface of the gingival flap.

6. Postoperative care
 - a. Amoxicillin 500 mg three times daily for 7 days or clindamycin 150 mg three times daily for 10 days
 - b. Three-day dexamethasone dose pack
 - c. Narcotic analgesics as required for pain
 - d. Wait 1 week and then use chlorhexidine gluconate mouth rinse for 10 to 14 days
 - e. Soft diet

To prevent bleeding and to ensure close adaptation tissues, pressure should be applied postoperatively to the donor site. Additionally, control of inflammation and minimizing of bruising are facilitated by application of ice to the donor site for the first day following the operation. After a week, the patient can use chlorhexidine mouth rinses twice daily for the next 2 weeks to reduce the risk of infection. Narcotic analgesics can be used to control the moderate pain at the donor site.

Note: Many patients experience reduced sensitivity to the chin or lower anterior teeth after the mandibular symphysis is used as a donor site, although the effects usually are minimal and frequently are only for 3 to 12 months. Nevertheless, patients must be duly informed. Sensory changes may result from stretching the mental nerve or disrupting the incisive canal contents, even when the clinician has maintained an appropriate border depth below the apices of the anterior tooth roots during harvesting. Proper procurement technique and careful selection of patients minimize this risk. The clinical procedures are depicted in Figures 28-1 through 28-14A-M).

II. Ramus grafts

(Indications: The primary indication is as a veneer graft to gain additional ridge width.)

A. Advantages

1. Morphology conforms well for veneer graft
2. No postoperative ridge alterations
3. No need for augmentation of the donor site because the masseter muscle provides soft tissue bulk, although it can be grafted
4. Minimal pain, edema, and swelling
5. Few postneurologic symptomatology in tissue or molars compared with chin grafts

B. Disadvantages

1. Mostly a thin cortical graft
2. Potential damage to the inferior alveolar nerve
3. Surgical access and visibility
4. Limitation of size and shape of the graft
5. Greater knowledge of anatomy required, especially of the mandibular canal

C. Limitation of ramus grafts

1. Clinical access
2. Coronoid process
3. Molar teeth impaction
4. Coronal position of the inferior alveolar nerve

D. Surgery

1. Preoperative evaluation
 - a. Radiographs
 - i. Panoramic radiograph
 - (a) Map course of the inferior alveolar nerve
 - (b) Evaluation of donor site
 - ii. Submental or posterior or interior projection: evaluation of ramus thickness
 - iii. Tomography
 - (a) Mapping surgical defect
 - (b) Determining mandibular canal path
 - (c) Useful adjunct for surgical planning and clinical evaluation
 - b. Clinical evaluation of donor site: What are you looking for?
2. Surgical technique



FIGURE 28-10 Hemostatic material (in this case, Avitene) is placed first to control bleeding. Particulate graft material is then placed over the Avitene.

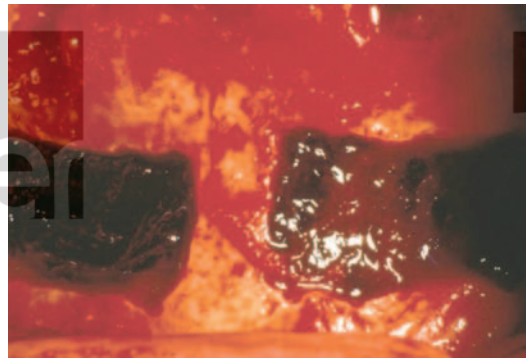


FIGURE 28-11 Once the blocks have been removed, hemostatic and particulate graft materials are placed in the donor site prior to a layered closure of the soft tissue.



FIGURE 28-12 Final suturing with 5-0 Vicryl.

- a. Surgical requirements
- i. This procedure requires a high degree of clinical skill and should not be attempted without thorough knowledge of mandibular anatomy to prevent nerve damage. Nerve damage can easily occur during bone cuts or sectioning.
 - ii. Canal anatomy: Although nerve positioning is variable, there are some anatomic averages to use as surgical guides.
 - (a) Mean superior-inferior width is 30.5 mm.
 - (b) Mandibular foramen is located two-thirds from the superior border.
 - (c) Mean distance from superior edge of canal to external oblique ridge:
 - (i) Second molar: 7 mm
 - (ii) Third molar: 11 mm
 - (iii) Base of coronoid process: 14 mm
 - (d) Medullary buccal bone thickness is greatest (mean 4.05 mm) at the distal half of the first molar. Therefore, grafts of smaller sizes are best harvested higher on the ramus, which usually decreases canal proximity, whereas with thick grafts, the anterior vertical cuts are best made in the distal half of the first molar. The length of the rectangle may approach 3.5 cm, but the height is usually not much greater than 1 cm.
- iii. Preoperative medication (see symphysis grafts)
- iv. Preoperative medications (see symphysis grafts.)
- b. Surgery procedure
- i. Local anesthesia
 - ii. Incision (flap design)
 - (a) The incision access to the ramus

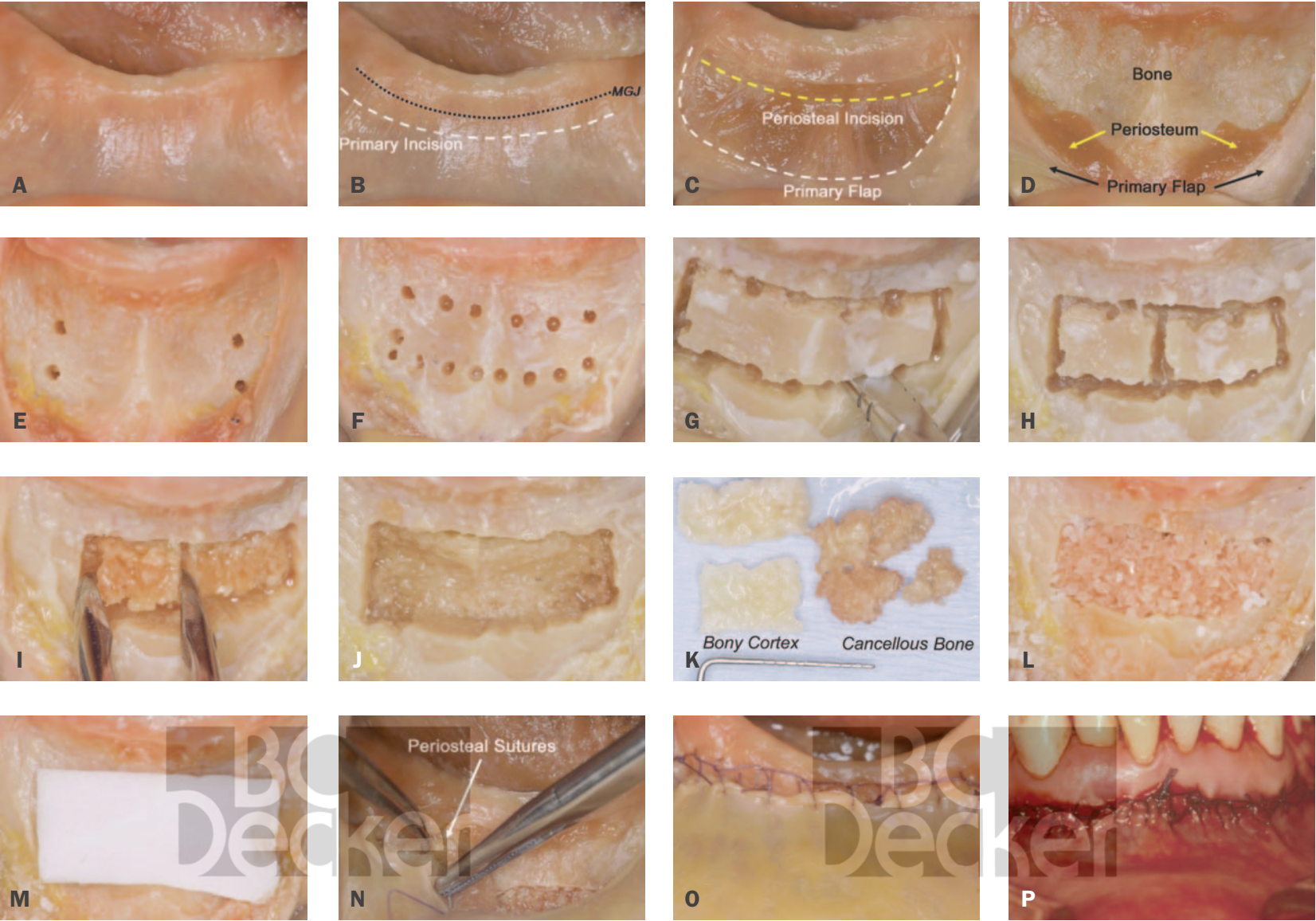


FIGURE 28-13 Basic technique on cadaver specimen. A, Preoperative view of the edentulous ridge. B, Preoperative view outlining MGJ and anticipated primary vestibular incision. Note extension of the flap to the cuspid area. C, Initial incision completed. Note reflection of the primary flap and exposure of underlying periosteal tissue. D, Flaps reflected to periosteum. Note that flaps have not been completely reflected to expose the full mandible. E, No. 4 or 6 round bur marks the lateral, apical, and incisal limits of the bone graft. F, The graft is outlined with multiple depth holes to facilitate graft removal. G, A flat elevator is used to help dislodge the bone graft. H, The holes are connected with a no. 1701 or Lindermann bur. I, The cortex has been removed, and the underlying cancellous bone is being removed with a small Friedman ronguer or Moldt curet. J, View of the lingual bone plate after removal of all cancellous bone. K, Comparison of cortical and medullary bone grafts. L, Bio-Oss graft placed into the donor site. M, Colacite positioned over the grafted donor site. N, Periosteal tissue is sutured first with 5-0 Vicryl. O, Suturing of periosteal tissue. P, Primary flap sutured with 4-0 or 5-0 Vicryl.

area for bone harvest begins in the buccal vestibule medial to the external oblique ridge and extends anteriorly and lateral to the retromolar pad (Figure 28-15).

- (b) It is begun on the ascending ramus no higher than the level of the occlusal plane, thus minimizing the possibility of cutting the buccal nerve and artery or exposing the buccal fat pad, as well as staying away from the terminal attachments of the temporalis muscle on the coronoid process.
 - (c) The incision is made in the buccal vestibule over the external oblique ridge and extends anterior and lateral to the retromolar pad either (Figure 28-16)
 - (i) in the mucosa, well beyond the mucogingival junction, or
 - (ii) in the buccal sulcus of the molar teeth and ends mesial of the first molar.
 - (d) For posterior edentulous patients, a split-thickness incision is continued to the most distal tooth.
 - (e) A full-thickness flap is reflected from the mandibular body to the inferior border, exposing the lateral border of the mandible.
 - (f) A notched ramus retractor is used to elevate the flap superiorly along the external oblique ridge to the base of the coronoid process.
- iii. Osteotomy for graft procurement, a procedure that is somewhat similar to the sagittal split osteotomy
- (a) External oblique osteotomy (Figures 28-16 to 28-19)
 - (i) The osteotomy is begun anterior to the coronoid process at a point where adequate thickness develops.
 - (ii) The harvesting procedure is initiated with a small round bur to mark the outline of the grafts to be drilled. The small holes will also serve as depth-cut markers so that the clinician can determine the thickness of the cortical plate.
 - (iii) A small fissure bur under copious irrigation in a surgical or high-speed handpiece

is used to connect the holes, through the cortex along the anterior border of the ramus and medial to the external oblique ridge, parallel to the outer surface to avoid a pie-shaped wedge.

- (iv) The osteotomy is extended anteriorly to the distal aspect of the first molar.
 - (v) A channel retractor is now positioned along the inferior border of the mandible to provide for flap retraction and visibility of vertical and apical osteotomies.
- (b) Vertical cuts
- (i) Anterior vertical cut: This cut is carefully and progressively made at the distal of the first molar into the mandibular body until bleeding is encountered, to avoid damage to the neurovascular bundle, which could be just under the cortex. **Note: The length of the cut is dependent on size requirements and the position of the inferior alveolar nerve.**
 - (ii) Superior horizontal cut: This cut is made on the lateral aspect of the mandible perpendicular to the external oblique osteotomy.
- (c) Inferior osteotomy: Access and visibility may be limited in this particular area, and because of this, the cuts in the mandible may be made shallow in this area with a small round bur (no. 4 or 6) and will serve as a fracture line. The cut should be superior to but not directly over the canal.

Note: In making the osteotomy cuts, the clinician should pay particular attention to the corners to ensure completeness of the cut. If not, the graft will be difficult to free.

- (d) Graft removal
- (i) A small chisel or splitting osteotomy instrument is “gently” maletted along the entire length of the osteotomy. It is “carefully” positioned

parallel to the lateral surface of the ramus to avoid damage to the molar roots and/or the inferior alveolar nerve.

- (ii) The buccal segment is freed with a wide, 8 mm, flat, 45°-angled chisel, which is positioned within the anterior ramus cut. The chisel is levered or rotated to complete the splitting of the graft from the ramus.

Note: If the graft is below the neurovascular bundle, separation should not be completed until it can be ensured that the neurovascular bundle is not entrapped within the graft.

- (iii) The graft is immediately placed in sterile saline until ready for use. **Note: Excessive delay in graft placement should be avoided.**
- (iv) Following graft removal, sharp edges around the ramus are smoothed with a bur or bone file.
- (v) Bone/wax or a hemostatic agent (collagen or gelatin sponge) is placed into the donor area. FDBA bone putty can then be used to fill in the donor site. Wound closure follows graft fixation.

3. Flap closure: interrupted sutures with 4-0 or 5-0 Gore-Tex or Vicryl sutures
4. The postoperative care is similar to that for mandibular grafts.

Note: Edema is very common following surgery, although its intensity may vary. In most cases, swelling decreases rapidly during the first 2 days postsurgery and complete dissipation occurs within 1 week. Postoperative trismus can be caused by excessive trauma during harvesting to the muscle fibers attached to the coronoid process, so it is important to minimize stripping of the flap superiorly beyond the area required for harvesting. Potential damage to the lingual nerve during flap incision can be avoided by placing the incision mid-crestally or slightly buccally over the retromolar pad area. (See Figures 28-15 to 28-19).

III. Allogeneic bone block grafts

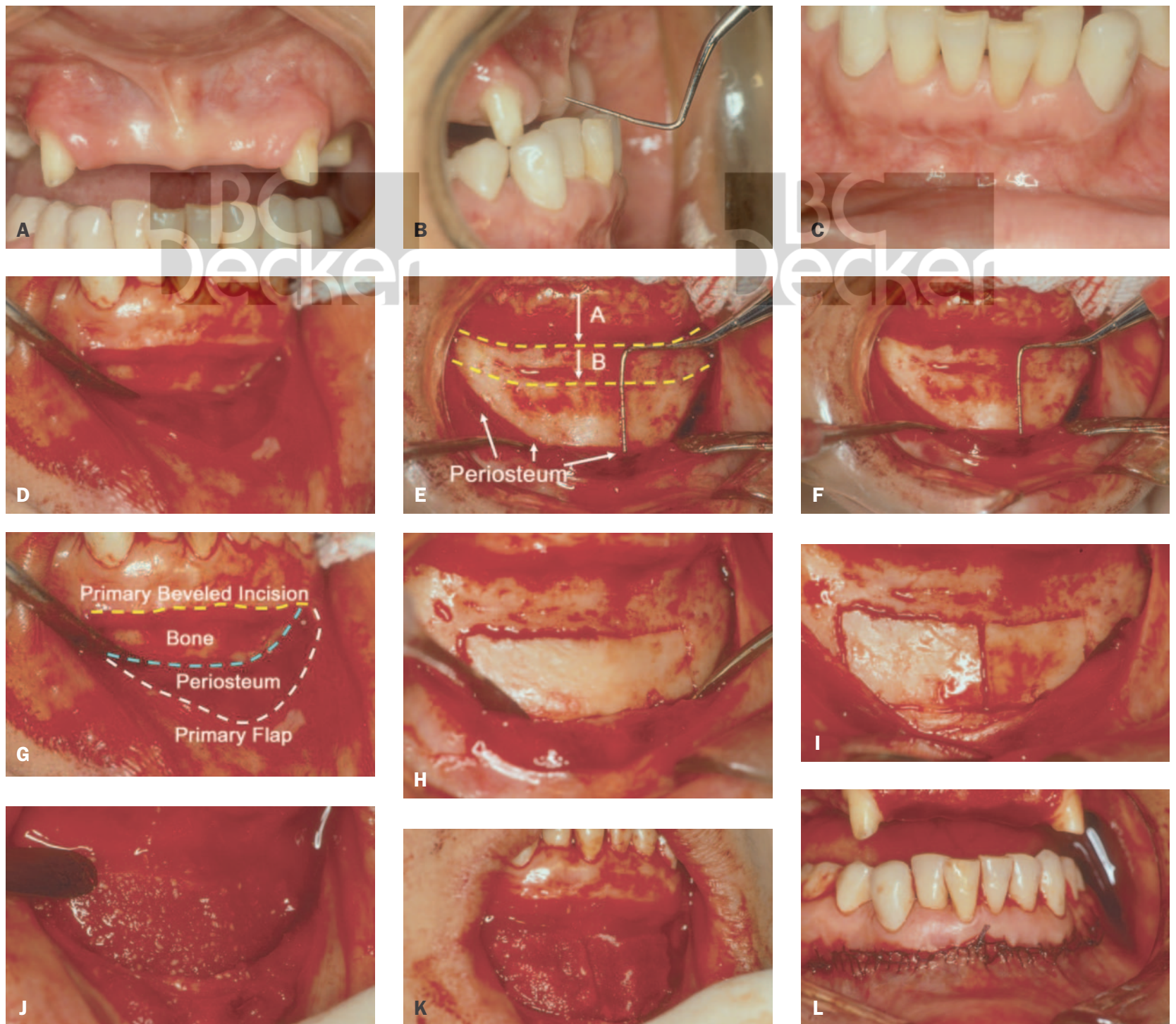


FIGURE 28-14 Preoperative facial (A) and side views (B) showing a Class III maxillary ridge relationship. C, Preoperative view of the lower donor site. D and E, Initial vestibular incision showing bone, periosteal, and primary flaps. F, Bone exposed with measurements to show the length of the teeth. G, A 5 mm margin below the roots. H, Full outline of the bone graft. I, Bone graft divided into two halves. J, Graft removed and site filled with demineralized freeze-dried bone allograft (DFDBA). K, Colatape placed over DFDBA. L, Flaps approximated and sutured with 5-0 Vicryl sutures.

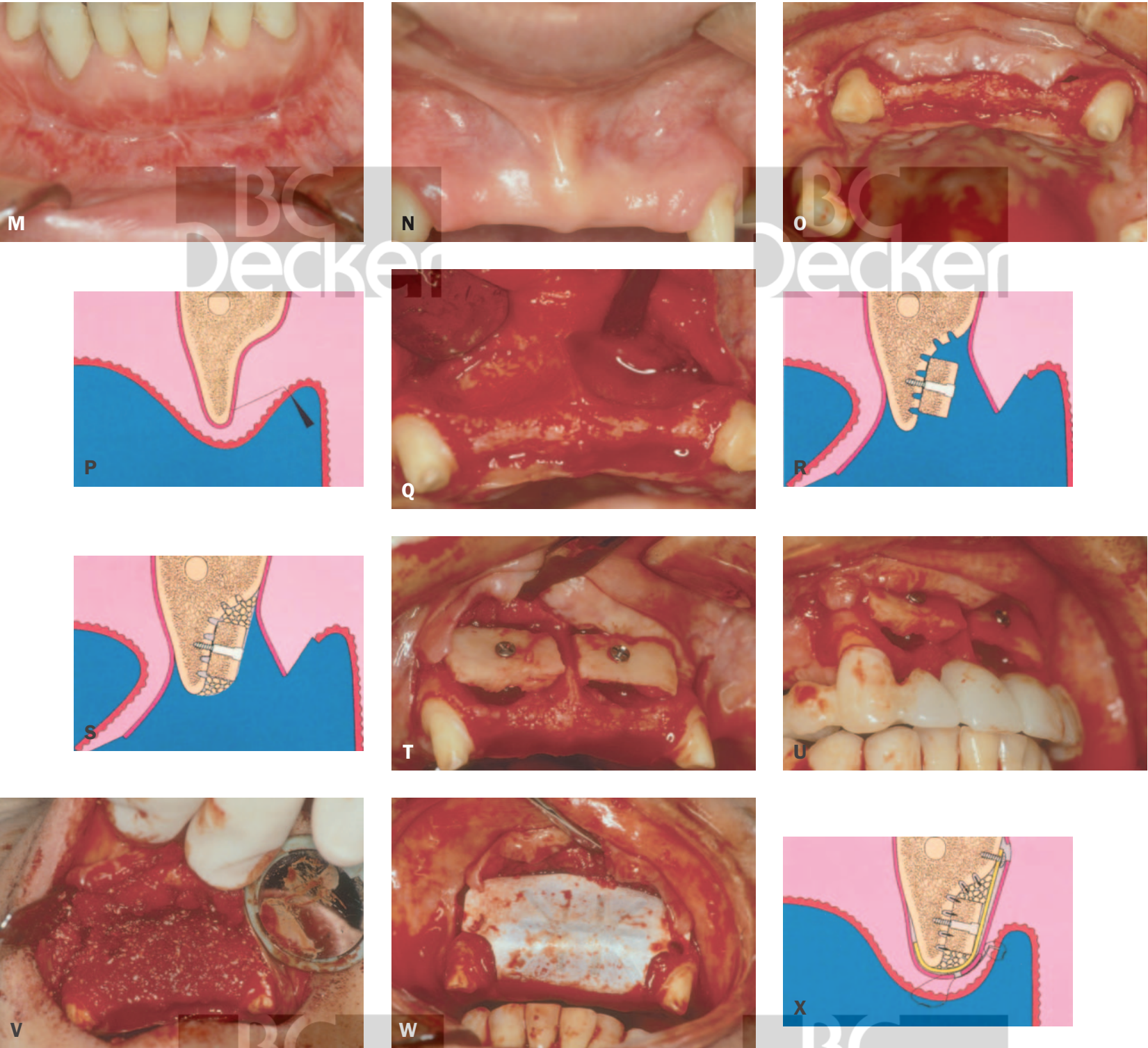


FIGURE 28-14 Continued. *M*, Final healing 2 months postoperatively. *N*, Preoperative maxillary view. *O*, Initial incision begun on the palatal side of the ridge. *P*, Diagram showing the incision for the defect. *Q*, Flap reflected to the nasal spine. Note the thin ridge. *R*, The graft is positioned on the ridge after decortification and stabilized with screws. *S*, The graft is mortised in with additional graft material to fill in the voids. *T*, Block graft positioned and stabilized with screws. *U*, Temporary bridge inserted to show a Class I ridge relationship. *V*, Block graft mortised in with DFDBA. *W*, Expanded polytetrafluoroethylene (e-PTFE) titanium membrane (Gore-Tex). *X*, A new membrane is positioned over the graft and sutured.



FIGURE 28-14 Continued. Y, Flap approximation and suturing with e-PTFE sutures. Note the tension-releasing suturing and complete flap closure. Z, Six months later, there is complete healing and the membrane, if nonresorbable, is removed. AA, Titanium Gore-Tex membrane prior to removal. BB, Facial (1) and occlusal (2) views showing a significant increase in ridge dimensions. CC, Lateral views showing a Class I relationship. Note the excellent pontic ridge relationship. DD, Flap sutured. EE, Final temporized bridge. (Diagrams courtesy of Straumann, USA. Slides courtesy of Dr. James Hanratty, Swampscott, MA.)

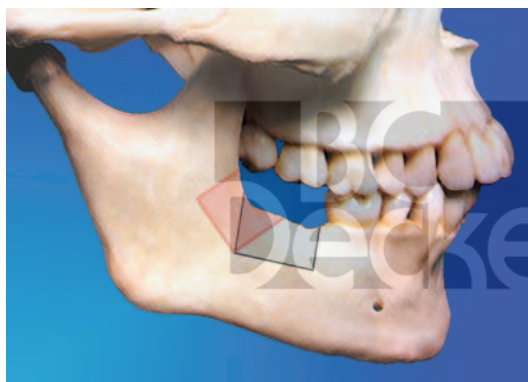


FIGURE 28-15 Bone from the ascending ramus or buccal shelf can be harvested from the gray area, the red area, or both depending on the size of the block required and the local dental and mandibular anatomy.

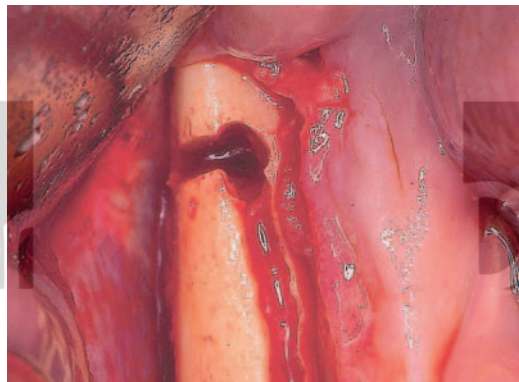


FIGURE 28-16 The flap has been reflected. The horizontal cut on the ridge and the vertical cuts have been made. The inferior horizontal cut is made with a no. 8 round carbide bur, which creates only a line in the cortical bone along which the bone will be fractured.



FIGURE 28-17 After the osteotomes are used, a chisel at a 45° angle is applied and lightly malletted.

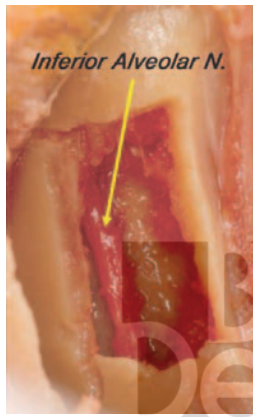


FIGURE 28-18 Bone graft harvested. Note the proximity of the inferior alveolar nerve.

A. Advantages

1. Less morbidity
2. Greater volume and dimension of bone available
3. Elimination of harvesting time

B. Disadvantages/contraindications

1. Should contain both the collagen aspect and mineral component of bone
2. Decortication of both graft and recipient site
3. Use of membrane barriers with the allogeneic block
4. Thorough rehydration of the allogeneic block in saline or nonactivated plasma-rich protein (Figures 28-20 to 28-29).

Recipient site: Preparation for symphysis, ramus, and allogeneic grafts

A. Preoperative requirements

1. Site must be completely healed prior to graft surgery.
2. Removal of foreign bodies, soft tissue surgery, and tooth extractions must be completed at least 8 weeks prior to grafting.

B. Surgical requirements

1. Defect should not be greater than five teeth
2. Defect should not be too extensive vertically

C. Procedure note: The proposed recipient site is exposed prior to graft harvest in all cases, thus allowing defect measurement and minimal elapsed time between graft harvest and placement.

1. Flap design

- a. With a no. 15 scalpel blade, a “beveled” incision is begun on the palatal side of the ridge for the maxilla and the labial or buccal side of the ridge for the mandible. The incision must be far enough away from the graft site so that the incision does not approximate the graft.
- b. The flap should be extended mesially and distally at least one tooth beyond the edentulous area. **Note: Careful handling of the tissue is recommended to avoid trauma and/or perforation.**
- c. Sulcular incision should be employed about the teeth.
- d. Vertical releasing incisions should be divergent to assure adequate blood supply and facilitate closure.
- e. In the anterior maxilla, a full-thickness

flap is raised to the anterior nasal spine, inferior and lateral to the rim of the nasal cavity and canine fossa region.

- f. A periosteal releasing incision is carefully performed to permit tension-free coronal positioning of the flap and to ensure complete graft closure. The releasing incision is made with a no. 15 scalpel blade or scissors at the base of the flap horizontally through the periosteum until the flap is released.
- g. Frenectomies may be considered for further release of flap tension. Care must be taken not to compromise the flap.

2. Graft fixation: Successful graft take is based on meticulous site and graft preparation and graft stabilization.

- a. The underlying bone is freed of all tissue tags and periosteum with a surgical curet.
- b. The recipient bone contour is evaluated and recontoured routinely to improve bone-to-graft contact (Figures 28-30 and 28-31).
- c. Decortification: With a small round bur



FIGURE 28-20 Most tissue banks can provide a variety of configurations of allogeneic tissues. In addition to powders, blocks of various sizes and shapes are available from most tissue banks.



FIGURE 28-21 When allogeneic tissues are used, the tissues must be obtained from a high-quality tissue bank that conducts a thorough medical history and autopsy of potential donors. It is also advisable to use tissues from a tissue bank that harvests tissues in a sterile operating room environment as shown.



FIGURE 28-19 The bone block is removed once it is free. The area should be inspected to ensure that the inferior alveolar nerve has not been affected. The donor site can optionally be grafted at this time with a putty allogeneic material.



FIGURE 28-22 Once allogeneic bone is harvested, it is cut to the appropriate sizes and shapes as requested by clinicians.



FIGURE 28-23 These harvested blocks undergo numerous steps to remove cells, lipids, and moisture.

(no. 4) and sterile saline, the recipient site is perforated a number of times through the cortical plate to open the marrow spaces, thus producing a bleeding surface, increased vascularization, influx of primordial cells, and graft take.

The undersurface of the graft is sometimes also perforated with a series of small holes, increasing the availability of osteogenic cells, expediting revascularization, and improving graft union. When using allogeneic blocks, it is especially important to perforate the entire block.

- d. Graft stabilization is achieved by use of small-diameter titanium alloy screws (BioHorizons). With a 1.6 mm pilot, the holes are drilled through the graft and into the underlying recipient site for maximum stabilization and with two holes if possible. The block graft itself is then drilled with a 2.0 mm drill. This drilling will permit the screws to pass

through the graft and then to engage the underlying bone. The cortical area of the screw hole should be slightly countersunk to allow for fit of the screw head. Graft stabilization is critical and will enhance primary stability with decreased resorption and increased vascularization.

Note: Two screws are recommended for greater stability and to prevent unintentional rotation.

See Figures 28-32 to 28-34.

- f. The graft is mortised, and harvested cancellous bone from the donor site or allogeneic particulate bone can be used to fill in small discrepancies.
3. Guided bone regeneration/membranes: Membranes should be used only when necessary because they may lead to complications if early exposure occurs. For allogeneic blocks, they should be used for all cases. Exposure of the membranes can result in
 - a. infection and/or

- b. smaller bone volume gain with premature removal.

4. Indications for membrane use
 - a. Incomplete fill of the defect by graft
 - b. To reduce graft resorption
 - c. To help contain and stabilize particulate grafts
 - d. To enhance bony regeneration of deficient areas
 - e. Always when using an allogeneic block graft
5. Contraindications for membrane use
 - a. When corticocancellous grafts completely or mostly occupy the defect
6. Suturing: interrupted Gore-Tex or Vicryl 4-0 sutures, left in for 2 weeks to ensure flap stability

The clinical cases are depicted in Figures 28-35 to 28-43.



FIGURE 28-24 Once cleaned of all soft tissues, they are washed in preparation for configuration. They can then be crushed to provide bone powders or cut with saws or a laser to provide blocks of various configurations.

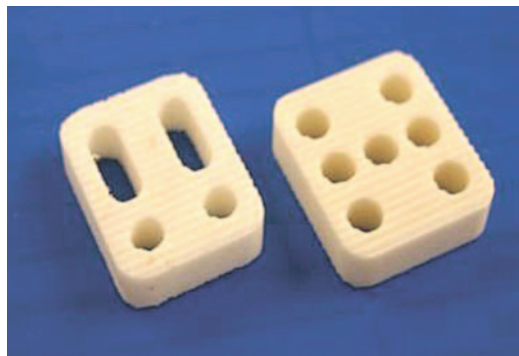


FIGURE 28-25 An example of a configuration of bone block provided for orthopedic bone grafting.



FIGURE 28-26 Another example of different allogeneic bone block configuration provided for orthopedic bone grafting.



FIGURE 28-27 Even intricate configurations of bone blocks are available from a tissue bank.

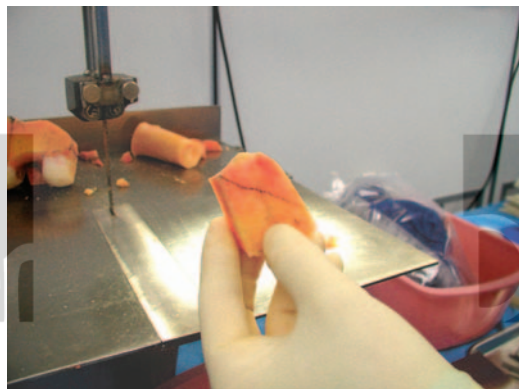


FIGURE 28-28 For most applications requiring grafting to a mandible or maxilla to increase width, the ridge is typically narrow at the top and widens apically, resembling a triangle. A triangle-shaped allogeneic bone block works well in these situations, with a narrow portion of the graft placed apically and the wider area placed at the top of the ridge.



FIGURE 28-29 An example of a commercial allogeneic bone block available for ridge augmentation prior to dental implant placement. Note the cortical side, which should be adjacent to the soft tissues on the buccal and occlusal aspects. The cancellous side should approximate the host bone of the prepared recipient site.



FIGURE 28-30 The harvested bone block is contoured to fit the recipient site. It is important to prepare the recipient site lightly to allow optimal adaptation of the block to the graft site.



FIGURE 28-31 The block has been harvested, contoured, and fit to the defect.



FIGURE 28-32 The quality screw-fixation kit shown here provides 1.6 mm screws in various lengths to accommodate the different thickness of bone blocks.



FIGURE 28-33 The screw-fixation kit must contain several drills in different diameters to allow for lagging the bone block and to have drivers that can fit onto the handle when access allows or to fit on the implant motor for areas of limited access.

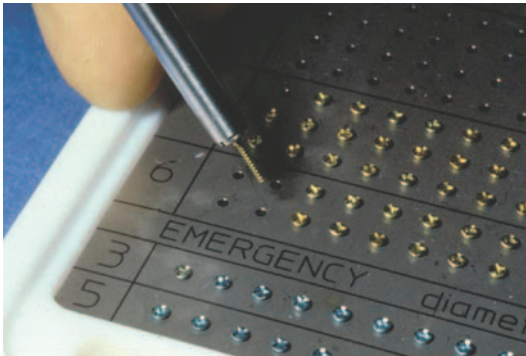


FIGURE 28-34 The driver tip must fit onto the screw head and engage it so that the screw and handle can be picked up with one hand, leaving the other hand free to hold the bone block securely to the recipient site.

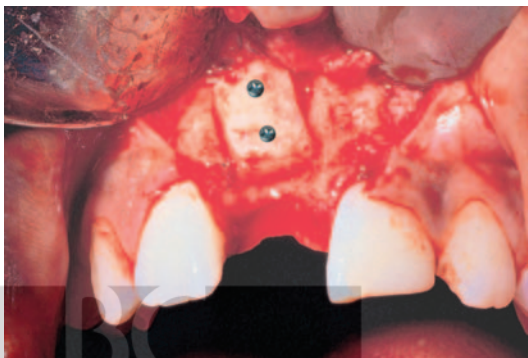


FIGURE 28-35 Two screws are recommended for block stability.

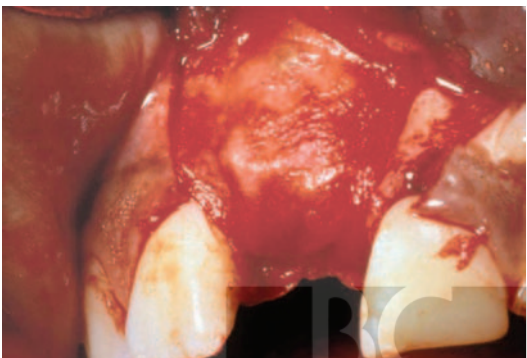


FIGURE 28-36 Six-month reentry showing complete ridge restoration.



FIGURE 28-37 The incision and flap should be extended mesially and distally at least one tooth beyond the area being grafted.

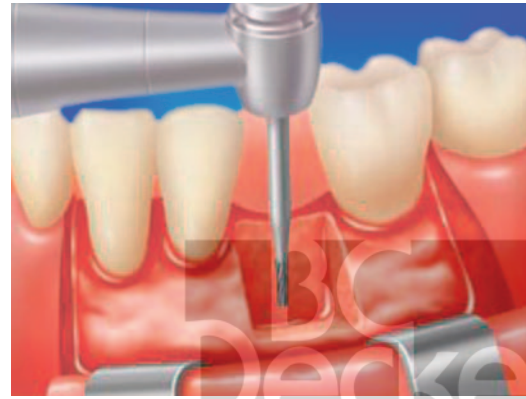


FIGURE 28-38 The recipient bone contour is evaluated and recontoured to accept the similarly recontoured block.

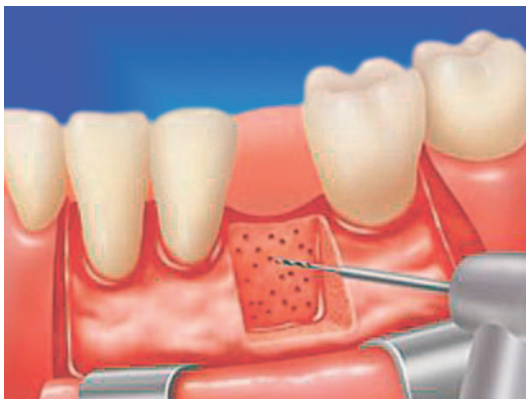


FIGURE 28-39 The recipient site is perforated a number of times to open the marrow spaces, thus producing a bleeding surface, for increased vascularization, influx, or primordial cells, and, ultimately, the graft take.



FIGURE 28-40 The bone block is contoured to fit into the recipient site. The undersurface of the graft is sometimes also perforated with a series of small holes, increasing the availability of osteogenic cells, expediting the rate of revascularization, and improving the rate of graft union.

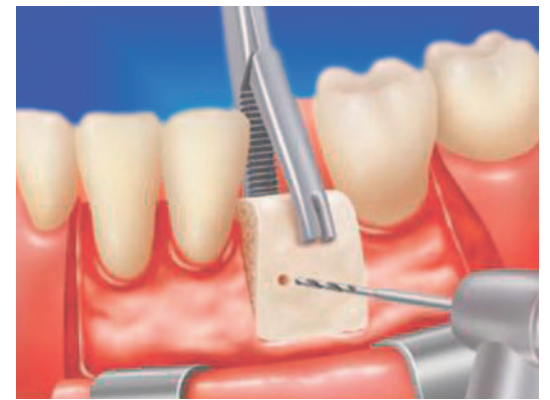


FIGURE 28-41 Graft stabilization is achieved by use of small-diameter titanium alloy screws. With a 1.6 mm pilot, the two holes are drilled through the graft and into the underlying recipient site for maximum stabilization. The block graft itself is then drilled with a 2.0 mm drill to allow for a lag of block fixation.



FIGURE 28-42 Drilling the block with a 2 mm drill and then using a 1.6 mm screw will permit the screws to pass through the graft and then to engage the underlying bone. The cortical area of the screw hole should be slightly countersunk to allow for fit of the screw head. Graft stabilization is critical and will enhance primary stability with decreased resorption and increased vascularization. The graft is “mortised” with cancellous bone from the donor site or allogeneic particulate bone to fill in small discrepancies.



FIGURE 28-43 Interrupted Gore-Tex or Vicryl 4-0 sutures are left in for 2 weeks to ensure flap stability.



Microsurgery

A therapeutic revolution has taken place in general surgery requiring the retraining of thousands of surgeons and the retooling of their operating rooms. This change has come about owing to the acceptance of microscopic surgery in many areas of medicine, such as vascular, corneal, otologic, neurologic, gynecologic, and, in particular, laparoscopic and arthroscopic procedures.

These procedures were a natural evolution of microsurgical advances and have become accepted as routine by the general public. Over the past decade, the field of periodontics has seen increasing surgical refinement of many procedures. Such refinements require more detailed surgical skills resulting from increased visual acuity. Consistent successful guided tissue regeneration, cosmetic crown lengthening, gingival augmentation procedures, soft and hard tissue ridge augmentation, osseous resection, and dental implants demand clinical expertise that challenges the technical skills of periodontists to the limits of and beyond the range of normal visual acuity.

Periodontal microsurgery has thus evolved. Periodontal microsurgery is not a specific operation intended to replace traditional periodontal surgery but a methodology that improves all aspects of surgical techniques. “Microsurgery” is defined as refinements in existing basic surgical techniques that are made possible by the use of the surgical microscope with subsequent, significant improved visual acuity. Traditional “macroscopic surgery” or “macrosurgery” is defined as those surgical procedures performed with the unaided eye, without the assistance of magnification.

Owing to the “visual advantage” gained with microsurgery, macrosurgery and microsurgery are not comparable. In macrosurgery, hand movements are guided proprioceptively, whereas in microsurgery, they are guided visually. These visually guided movements not only position the hands for the execution of prelearned movements but also through their entire range of motion, with visual feedback and midcourse corrections. Visually guided movements result in greater accuracy of hand movements, which are retrained with use and practice. Microscopically visually guided movements allow the periodontist to achieve clinical results once thought unlikely on a consistent basis.

Optical magnification has, therefore, broadened the horizons of dentistry in general and periodontics in particular. Improvement in visual acuity, made possible through optical magnifi-

cation, has become an integral part of modern dental practices.

Magnification Systems

A variety of simple and complex magnification systems are available to practitioners, ranging from simple loupes to prism telescopic loupes and, ultimately, to the surgical microscope. Each magnification system has specific advantages and limitations. When selecting which mode of magnification should be used for improved visual acuity, the task at hand must be considered. The assumption that more magnification is better must be weighed against the decrease in field of view and depth of focus that occurs as magnification increases (Figure 29-1). Therefore, an understanding of the optical principles that govern magnification is essential to the successful use of magnification in the clinical practice of dentistry. Microdentistry and periodontal microsurgery are acquired skills, requiring magnification, microsurgical instruments, intensive training, and frequent practice to achieve and maintain excellence.

Magnifying Loupes

Surgical loupes are the most common system of optical magnification used in dentistry. Fundamentally, loupes are two monocular microscopes with side-by-side lenses converging to focus on the operative field. The magnified image is formed with stereoscopic properties by virtue of the convergent lenses. A convergent lens system is called a keplerian optical system (Figure 29-2).

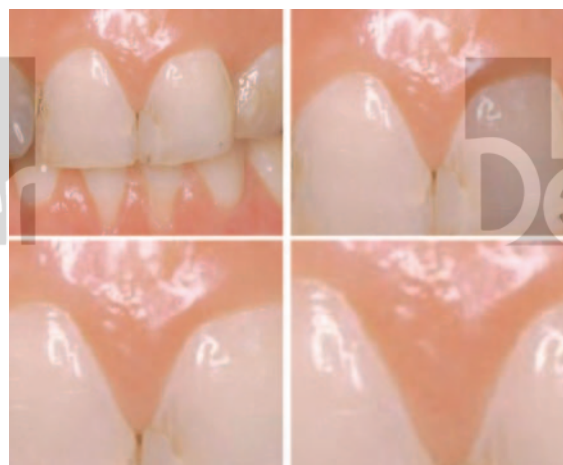


FIGURE 29-1 Magnifications (clockwise from upper left) 2×, 4×, 8×, and 16×.

Three types of keplerian loupes are commonly employed in dentistry: simple single-element loupes (Figures 29-3 and 29-4), compound loupes (Figures 29-5 and 29-6), and prism telescopic loupes (Figures 29-7 and 29-8). Each type may differ widely in optical sophistication and individual construction (Table 29-1). For most periodontal procedures performed using loupe magnification for increased preciseness, either compound or prism loupes, of $\times 4$ to $\times 5$ magnification, are used to provide the most effective combination of magnification, field size, and depth of focus.

Simple Loupes

Simple loupes consist of a pair of single, positive, side-by-side meniscus lenses (see Figure 29-4). Such loupes are primitive magnifiers, with limited capabilities. Each lens has two refracting surfaces, with one occurring as light enters the lens and the other when it leaves. The magnification of simple loupes can be increased only by augmenting the lens diameter or thickness. Because of their size and weight limitations, they have no practical dental application beyond a magnification range of 1.5 diameters, where working distances and depths of field are compromised.

Compound Loupes

Compound loupes (see Figure 29-6) are converging multiple lenses with intervening air spaces to gain additional refracting power, magnification, working distance, and depth of field. They are also “achromatic” (color correct), which is highly desirable. Size and weight are not significant

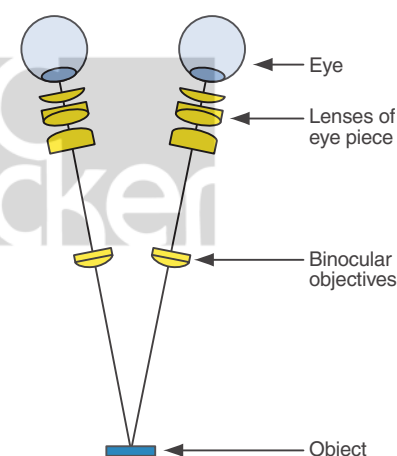


FIGURE 29-2 Keplerian optics.



FIGURE 29-3 Simple loupes.

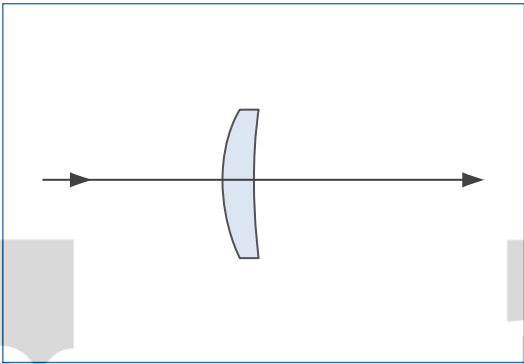


FIGURE 29-4 Simple loupe optical diagram.



FIGURE 29-5 Compound loupes.

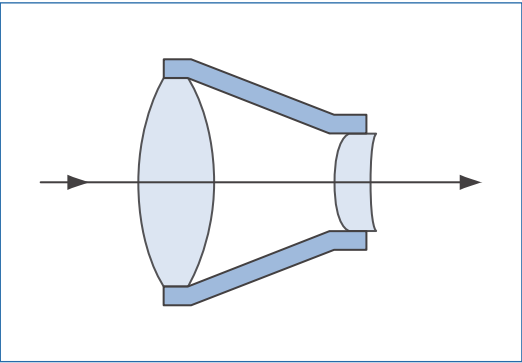


FIGURE 29-6 Compound loupe optical diagram.



FIGURE 29-7 Eyeglass-mounted prism loupes.

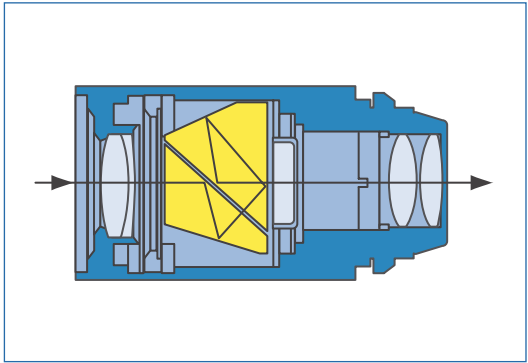


FIGURE 29-8 Prism loupe optical diagram.

problems for the $\times 4$ to $\times 5$ magnification commonly used in periodontics.

Prism Loupes

Prism loupes are the most optically advanced type of loupe magnification presently available (see Figure 29-8). Prism loupes contain Schmidt or rooftop prisms, which lengthen the light path through a series of mirror reflections within the loupes, virtually folding the light so that the barrel of the loupe can be shortened. Only the surgical microscope can provide better magnification and optical characteristics than prism loupes.

Operating Microscope

The surgical operating microscope is much more versatile and advantageous than magnifying loupes (Table 29-2). The microscope offers multiple flexibility in magnification optics and comfort (Figure 29-9). Operating microscopes suitable for use in periodontics use galilean optical principles (Figure 29-10).

Such scopes use the application of the magnifying loupe in combination with a magnification changer and a binocular viewing system so that the scopes employ parallel binoculars for protection against eye strain and fatigue. They

should also incorporate fully coated optics and achromatic lenses, with high resolution and good contrast stereoscopic vision.

Maneuverability

For practical use in periodontics, a surgical microscope must have maneuverability, stability, and an adequate working distance for instrumentation. Microscope mountings play an important role in maneuverability and scope stability and are available for the ceiling, the wall, or a floor stand.

Maneuverability must always be sufficient to meet the requirements of clinicians for increased visual accessibility to the various anatomic structures dealt with in periodontics. Inclined eyepieces are an indispensable necessity for the maneuverability and flexibility necessary for the clinical use of the surgical microscope in periodontics. Because the optical characteristics of most manufacturers' lenses are comparable, microscope maneuverability is often more important than optical characteristics in determining the appropriate microscope for periodontal procedures (Figures 29-11 and 29-12).

Illumination

Illumination of the field is an important consideration. Periodontists are accustomed to lateral illumination from side-mounted dental lights. Clinicians who work with loupes often require a

Table 29-1 Keplerian Loupes				
Type	Lens	Maximum Usable Magnification	Advantages	Disadvantages*
Simple	Single	1.5 \times	Simplicity	Spherical (shape) and chromatic (color) distortions with increased size and weight increased magnifications
Compound	Multiple	3.0 \times	Increased magnification	Limited depth of field Limited field access
Prism	Multiple	4.0 \times	Higher magnification Wide depth of field Longer working distances Larger fields of view	Increased weight above 4 \times

*A major disadvantage of the design of keplerian loupes is that the clinician's eyes must converge to view the operative field. This can result in eye strain, fatigue, and even vision changes, especially after prolonged use of poorly fitted loupes.

Table 29-2 Operating Microscope				
Type	Lens	Maximum Usable Magnification	Advantages	Disadvantages
Microscopic	Multiple	4–20×	Binocular eyepieces Parallel optical eyepieces permit relaxed stereoscopic viewing Achromatic (color stable) lenses High resolution Efficient illumination Increased depth of field Increased field of view Ability to easily change magnification	Fixed positioning of patient High initial setup costs Limited site use to 60–80%

headlamp to compensate for the decreased amount of light passing through the loupes. Until recently, coaxial fiber optic illumination had been a major advantage of the operating microscope over surgical loupes. Coaxial lighting places the light source parallel to the optical axis via a prism beam splitter. With coaxial lighting, no shadows are produced, and the clinician can better view into the farthest reaches of the oral cavity, including into some subgingival pockets and angular defects. Improved visualization of root surface irregularities and deposits is possible. The clinician is often able to view aspects of both normal and abnormal periodontal anatomy never previously accessible. Clinical decisions can be made based on improved visual knowledge of altered anatomy rather than educated guesses. Coaxial lighting has also become available in prism telescopic loupes.

Documentation

Documentation of periodontal procedures has become increasingly important for both dental-legal reasons and for patient and professional education purposes. The surgical operating microscope is ideal for documenting periodontal

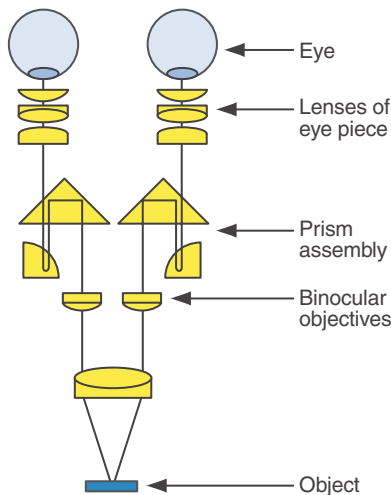


FIGURE 29-10 Galilean optics microscope diagram.



FIGURE 29-9 Operating microscope.



FIGURE 29-11 Microscope on a rotating mount.



FIGURE 29-12 Periodontal operatory equipped for microsurgery.

procedures of all types: either 35 mm slides or digital photographs can be easily produced using a beam splitter camera attachment (Figure 29-13). With a foot-operated shutter control, the surgeon can compose the photographic field as the procedure unfolds without interrupting the surgical process for photography. An advantage of microscopic photography is that it represents the surgical field exactly as the surgeon sees it as opposed to a photographer's view produced from a different angle while the surgeon works. Excellent video documentation is also available through the operating microscope using a video beam splitter attachment. High-resolution digital cameras with video and slide printers are currently replacing 35 mm camera photography in many microsurgical disciplines. High-resolution S-VHS recorders bring new capabilities for video recording of periodontal procedures for educational purposes.

Periodontal Microsurgery

In recent years, periodontics has witnessed increasing refinement and consistency of procedures, requiring progressively more intricate surgical skills. Regenerative and resective osseous surgery, periodontal plastic surgery, and dental implants demand clinical performance that challenges the technical skills of periodontists beyond the range of ordinary visual acuity.



FIGURE 29-13 Microscope camera and beam splitter.

Periodontal microsurgery introduces the possibility for considerably less invasive surgical procedures in periodontics, exemplified by smaller, more precise surgical incisions for access and, consequently, less need for vertical releasing incisions. Periodontists, like other microsurgeons, have been surprised by the extent to which reduced incision size is directly related to reduced postoperative patient pain.

Advantages

- 1. Less tissue trauma
 - 2. Less mobility
 - 3. Less patient anxiety
 - 4. Atraumatic tissue management
 - 5. Accurate primary wound closure
 - 6. Increased diagnostic skills
 - 7. Minimally invasive
 - 8. Improved cosmetic results
 - 9. Increased surgical quality
 - 10. Increased effectiveness of root débridement results in greater predictability of
 - a. Regeneration procedures
 - b. Cosmetic procedures
- Improved documentation
- a. Video
 - b. Slide
 - c. Digital

Disadvantages

- 1. Educational requirements
 - a. Surgical technique
 - b. Understanding of optics
- 2. Long adjustment period for clinical proficiency
- 3. Initial increased surgical time
- 4. Higher patient cost
- 5. Limited surgical access

Microsurgical Instruments

In addition to the use of magnification and reliance on atraumatic technique, microsurgery entails the use of specially constructed microsurgical instruments specifically designed to minimize trauma (Figures 29-14 and 29-15). An important characteristic of microsurgical instruments is their ability to create clean incisions to prepare the wound for healing by primary intention. Such incisions are established at 90° angles to the surface using a Castroviejo microsurgical scalpel (Figure 29-16). Magnification permits easy identification of ragged wound edges for trimming and freshening. To permit primary wound closure, microsutures in the range of 6-0 to 9-0 (Figure 29-17) with microsurgical needle holders are required to correctly approximate the wound edges (Figure 29-18). Microsurgical wound apposition minimizes gaps or voids at the wound edges, which encourages rapid healing, with less postoperative inflammation and less pain.

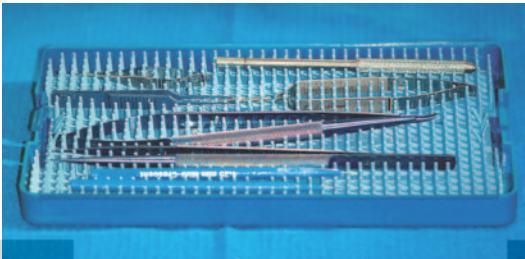


FIGURE 29-14 Microsurgical instruments.



FIGURE 29-15 Castroviejo microsurgical scalpel.

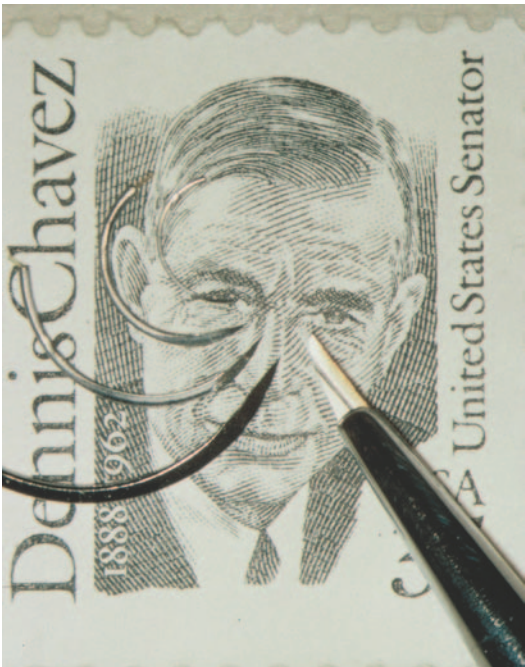


FIGURE 29-16 Microsutures and microinstruments at ×10 magnification.

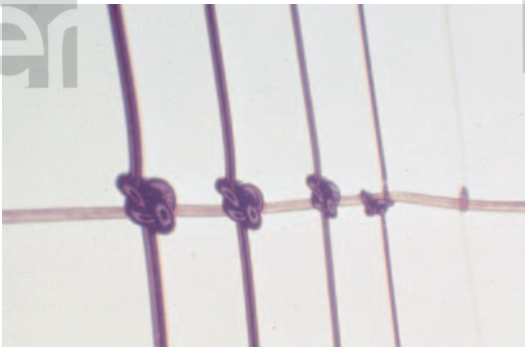


FIGURE 29-17 Sutures in human hair.

Conclusions

Viewing periodontal surgery under magnification cannot help but impress the clinician with the coarseness of conventional surgical manipulation. What appears to the unaided eye as gentle handling is revealed, under magnification, as gross crushing and tearing of delicate tissues. Periodon-

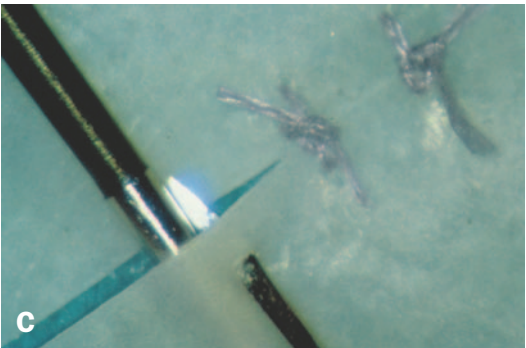
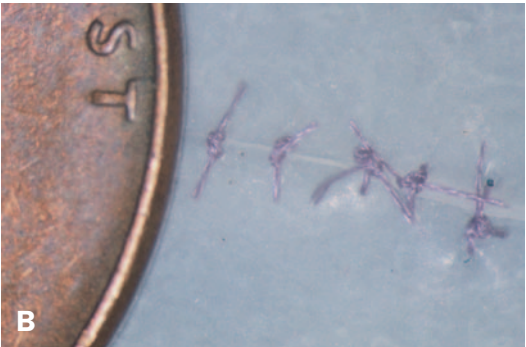


FIGURE 29-18 A, Suture practice on latex at ×8 magnification. B, Suture practice on latex at ×24 magnification. C, Suture practice on latex at ×32 magnification. D, Suture practice on foliage (anthurium flower) at ×32 magnification.

tists have attempted to treat the surgical site atraumatically to achieve primary wound closure. However, the limits of normal vision dictate the extent to which this goal is possible. For surgeons who perform periodontal surgery to continue to live up to their reputation of being experts in deftly handling soft and hard tissues, proficiency in periodontal microsurgery is a necessity.

Periodontal surgery is a natural extension of conventional surgical principles by which magnification is employed to permit accurate and atraumatic handling of soft and hard tissues to enhance wound healing.

Figures 29-19 to 29-21 illustrate periodontal surgery cases treated using microsurgical techniques.

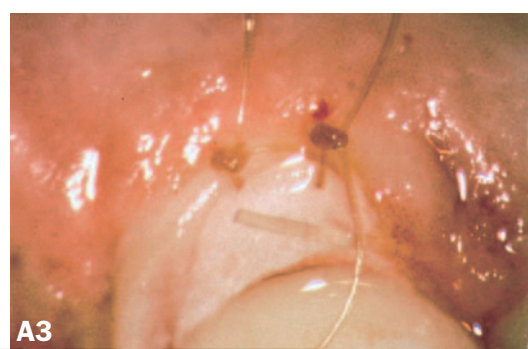


FIGURE 29-19 A, 1, Deep-wide gingival recession on maxillary cuspid. 2, Microsurgical subepithelial connective tissue graft $\times 4$ magnification. 3, Same case viewed at $\times 20$ magnification. 4, Final postoperative result. B, 1, Multiple areas of recession (central incisor and cuspid). 2, Microsurgical subepithelial connective tissue graft sutured with minimal trauma. 3, One-month postoperative result.

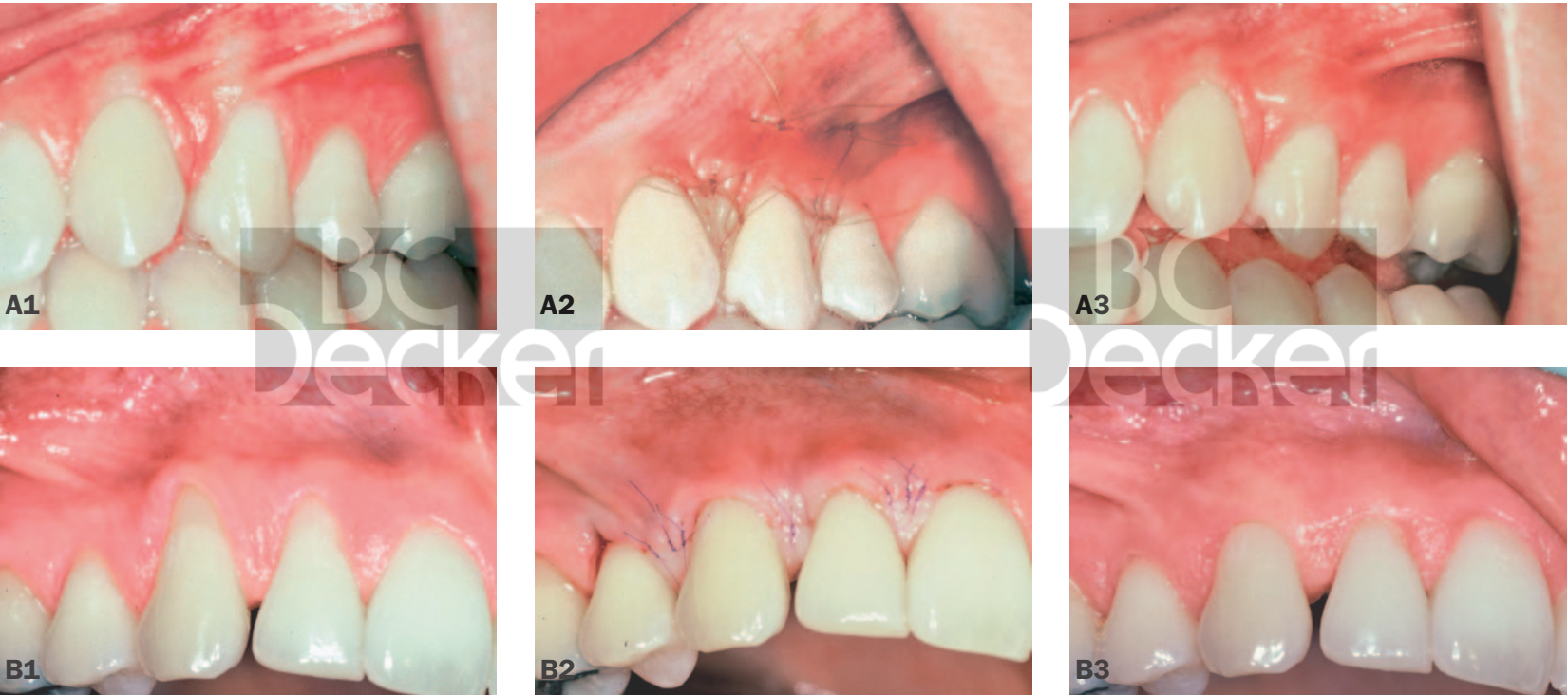


FIGURE 29-20 A, 1, Mucogingival frenum abnormality with slight recession. 2, Subepithelial microsurgery to reposition the frenum and augment attached gingiva with a connective tissue graft. 3, One-month postoperative result. B, 1, Multiple areas of gingival recession. 2, Microsurgical subepithelial connective tissue graft with a coronally positioned flap. 3, Final result with 100% root coverage.



FIGURE 29-21 A, 1, Papilla reconstruction prior to surgery. 2, Microsurgical view of papillary reconstruction. 3, Papillary reconstruction completed. B, 1, Significant recession on the canine tooth. 2, Microsurgical subepithelial connective tissue graft coverage by a double-papilla flap. 3, Complete root coverage with a wide zone of keratinized gingiva, 3-month result.

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